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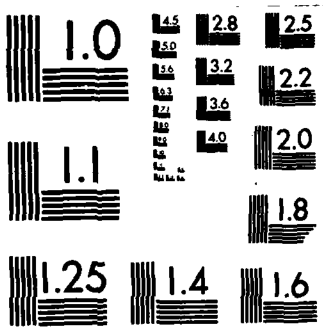

MICROCOPY RESOLUTION TEST CHART
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Southwestern Division

Reservoir Control Center

AD-A156 496

(Instream Flow Study)

PART III OF THE

ANNUAL REPORT

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USArmy Corps of Engineers
Southwestern Division
Dallas, Texas

January 1981

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents activities and accomplishments of the Southwestern Division (SWD) related to reservoir regulation and water management through FY 1980. ~~Companion~~ publications, "Parts II and III ~~of the~~ "Annual Report", have been prepared containing detailed summaries of the districts, and minutes of coordinating committee meetings, and instream flow problems and needs evaluation, respectively.

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PART III

RESERVOIR CONTROL CENTER

1980 ANNUAL REPORT

PART I

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PART I

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ADDENDA

PLATE

SECTION IX - INSTREAM FLOW STUDY

1. Summary of Instream Flow Problems and Needs. The instream flow problems and needs evaluation program established by OCE is in response to President Carter's 12 July 1978 memorandum on "Environmental Quality and Water Resources Management". The EC directs all field operating activities having civil works projects responsibilities to conduct a project evaluation of all existing Corps of Engineers water resources projects. The evaluations will be used to assess the magnitude of existing instream flow related problems and needs, the potential cost necessary to meet the identified needs, the opportunities to enhance instream flow affected to accomplish necessary actions. Criteria for the evaluations are contained in EC 1110-2-214 and with further guidance provided by SWDED-XR letter dated 18 August 1980 (Appendix A).

The Southwestern Division Office established a program in mid 1978 to determine minimum flow requirements for fish and wildlife purposes below Corps projects. Several problem areas were determined. Minimum flows were initiated at several projects as a result of that program. Another result was the initiation of studies of several other projects to determine the need for minimum flow and the magnitude of those flows. The Southwest Division has been working with the US Fish and Wildlife Service in an attempt to arrive at a mutually acceptable solution to these problems within present operational constraints. Some of the quantity information required by the EC had therefore been compiled.

The instream flow evaluation program within Southwestern Division has resulted in the evaluation of 84 of the 93 projects. Those omitted are eight low lift navigation structures on the main stem of the Arkansas River and one on the Arkansas Post Canal. These projects have no apparent water quality or water quantity problems associated with project regulation. Low flows on the main stem of the Arkansas River are controlled by hydropower operations at upstream storage and run of river projects. Release requirements are set at the Dardanelle power station which results in adequate minimum flows downstream except under extreme drought conditions.

The number of projects to be evaluated varied tremendously between districts with Galveston District having only two projects to evaluate while Tulsa District had 44. The amount of detail included also varies from district to district. Little Rock and Fort Worth Districts presented a considerable amount of detail on most projects. Tulsa District, due to the large number of projects, grouped projects according to reservoir size and depth, location and outlet works configuration with generalized descriptions for the water quality portions plus known specific problems for individual projects. Of those evaluated about twenty within SWD were described as having no water quality problems or at least none noted to date. Most of these are low lift locks and dams along the McClellan-Kerr Arkansas River Navigation Project. Others are small flood control and conservation projects that do not stratify or if they do it is a mild stratification that is easily broken up by wind action.

Eight projects are currently being studied as part of larger more comprehensive basin restudies or site specific studies to address known high profile problems. Three site specific studies are at Lake Texoma (Denison Dam), Sam Rayburn Dam and Table Rock Dam. These three have been identified by state agencies as having low dissolved oxygen in their releases. An additional study is proposed for Lake Texoma.

Quantity wise, numerous projects have no or extremely low releases for extended periods of time. In appropriated rights states (Texas and New Mexico) most releases, other than for flood control, are made at the request of compact commissions or other state or local agencies having rights to the stored or inflowing waters. Therefore, in most cases, the Corps has no authority to release conservation water for other uses. Even in other states much of the conservation storage is under contract to local governmental agencies and therefore cannot be used to enhance downstream areas.

Twenty projects were identified as having problems severe enough that the districts recommended studies to determine the extent of the problem and alternative solutions. Seven of these are water quantity problems identified by the US Fish and Wildlife Service. The others are water quality problems generally associated with deep stratified impoundments with low level outlets. They are generally low dissolved oxygen, high temperature in trout fisheries, hydrogen sulfide, iron, manganese or pH. Many other reservoirs screened in this program had similar problems but they are not as severe as those indicated.

Table 1 shows projects where studies are recommended including priorities and funding requirements.

PROJECT	PRIORITY	FUNDS
Tenkiller Ferry	1	$30,000
Lake Texoma (Denison Dam)	2	50,000
Sommerville	3	50,000
Nimrod	4	35,000
Keystone	5	30,000
Oologah	6	30,000
Wister	7	20,000
Blue Mountain	8	15,000
Eufaula	9	15,000
Broken Bow	10	15,000
Lavon	11	60,000
Bardwell	12	60,000
Navarro Mills	13	55,000
Proctor	14	55,000
Belton	15	50,000
Stillhouse	16	55,000
Clearwater	17	10,000
Hugo	18	15,000
Greers Ferry	19	20,000
Pine Creek	20	15,000

The Southwestern Division evaluation process required a large expenditure of resources which due to the time frame involved had to be diverted from other programs. These programs are being rescheduled as quickly as manpower and funding allow. The evaluations are, in some instances, the first comprehensive look at problems encountered at the projects. In some districts personnel from Hydraulics, Planning, Operations and project personnel cooperated in the effort to identify all known problems. We feel that this study evaluation will serve as basis for future work to improve the quality and quantity of releases from SWD projects.

2. Detailed Project Evaluation of Instream Flow Problems and Needs. Narratives describing detailed evaluations for individual projects are contained in this volume. An index is shown on pages 4a through 4e.

3. Monthly Discharge - Frequency and Discharge-Duration Relations. Monthly discharge - frequency and discharge - duration curves are included in Appendix A for those projects that were evaluated. Projects are in the order shown on pages 4a and 4b.

INSTREAM FLOW PROBLEMS AND NEEDS EVALUATION INDEX

LAKE NAME	STREAM	DIST	STATE	YR COMP	POOL ELEVATION CONS	POOL ELEVATION FC	CAPACITY 1000 AF CONS	CAPACITY 1000 AF FC	PAGE NO
Introduction									1
			WHITE RIVER BASIN						
Beaver	White	LRD	AR	66	1120.0	1130.0	1652	300	5
Table Rock	White	LRD	AR/MO	58	915.0	931.0	2702	760	526
Bull Shoals	White	LRD	AR/MO	52	654.0	695.0	3048	2360	15
Norfork	North Fork	LRD	AR/MO	45	552.0	580.0	1251	732	26
Clearwater	Black	LRD	MO	48	494.0	567.0	22	391	36
Greers Ferry	Little Red	LRD	AR	62	461.0	487.0	1911	934	44
			ARKANSAS RIVER BASIN						
Pueblo	Arkansas R	AD*	CO	74	4880.6	4898.7	264	93	
Trinidad	Purgatoire R	AD	CO	78	6226.4	6260.0	64	58	55
John Martin	Arkansas	AD	CO	51	3851.0	3870.0	351	270	57
Cheney	N F Ninnescah	TD*	KS	64	1421.6	1429.0	167	81	
Eldorado	Walnut	TD	KS	80	1339.0	1347.5	157	79	59
Kaw	Arkansas	TD	OK/KS	76	1010.0	1044.5	429	919	64
Great Salt Plains	Salt Fork Ark	TD	OK	41	1125.0	1138.5	31	240	70
Keystone	Arkansas	TD	OK	64	723.0	754.0	618	1219	77
Heyburn	Polecat Cr	TD	OK	50	761.5	784.0	7	48	86
Toronto	Verdigris R	TD	KS	60	901.5	931.0	22	178	94
Fall River	Fall	TD	KS	49	948.5	987.5	24	235	102
Elk City	Elk	TD	KS	66	792.0	825.0	34	256	110
Big Hill	Big Hill Cr	TD	KS	81	858.0	867.5	27	13	120
Oologah	Verdigris R	TD	OK	63	638.0	661.0	553	966	125
Hulah	Caney	TD	OK/KS	51	733.0	765.0	36	258	136
Copan	L Caney	TD	OK/KS	80	710.0	732.0	43	184	146
Birch	Birch Creek	TD	OK	79	750.5	774.0	19	39	151
Skiatook	Hominy Creek	TD	OK	82	714.0	729.0	305	182	156
Newt Graham LD 18	Verdigris	TD	OK	70	532.0	-	24	0	161
Chouteau LD 17	Verdigris	TD	OK	70	511.0	-	23	0	163
Council Grove	Neosho R	TD	KS	65	1270.0	1289.0	38	76	165
Marion	Cottonwood R	TD	KS	68	1350.5	1358.5	86	60	175
John Redmond	Neosho R	TD	KS	64	1039.0	1068.0	82	563	189
Grand Lake	Neosho (Grand)	TD*	OK	40	745.0	755.0	1672	525	
Lake Hudson	Neosho (Grand)	TD*	OK	64	619.0	636.0	200	244	
Fort Gibson	Neosho (Grand)	TD	OK	52	554.0	582.0	365	919	198
Webbers Falls LD 16	Arkansas	TD	OK	70	490.0		165	0	208
Tenkiller Ferry	Illinois R	TD	OK	52	632.0	667.0	654	577	210
Conchas	Canadian R	AD	NM	39	4201.0	4218.0	330	198	221
Meredith	Canadian R	TD*	TX	65	2941.3	2965.0	945	463	
Thunderbird	Little R	TD*	TX	65	1039.0	1049.4	120	77	
Optima	N Canadian R	TD	OK	78	2763.5	2779.0	129	101	223
Fort Supply	Wolf Cr	TD	OK	42	2004.0	2028.0	14	87	228
Canton	N Canadian R	TD	OK	48	1615.2	1638.0	116	268	234
Eufaula	Canadian R	TD	OK	64	585.0	597.0	2329	1470	242
R S Kerr LD 15	Arkansas	TD	OK	70	460.0	-	494	0	251
W D Mayo LD 14	Arkansas	TD	OK	70	413.0	-	16	0	253
Wister	Poteau R	TD	OK	49	471.6	502.5	27	400	255
LD 13	Arkansas	LRD	AR/OK	69	392.0	-	54	0	
Ozark-J T LD 12	Arkansas	LRD	AR	69	372.0		148	0	504
Dardanelle LD 10	Arkansas	LRD	AR	64	338.0	-	486	0	511
Blue Mountain	Petit Jean	LRD	AR	47	384.0	419.0	25	233	266
LD 9	Arkansas	LRD	AR	69	287.0	-	65	0	
Toad Suck Ferry LD 8	Arkansas	LRD	AR	69	265.0	-	35	0	
Nimrod	Fourche La Fave	LRD	AR	42	342.0	373.0	29	307	273
Murray LD 7	Arkansas	LRD	AR	69	249.0	-	87	0	
D D Terry LD 6	Arkansas	LRD	AR	68	231.0	-	50	0	
LD 5	Arkansas	LRD	AR	68	213.0	-	65	0	
LD 4	Arkansas	LRD	AR	68	196.0	-	70	0	
LD 3	Arkansas	LRD	AR	68	182.0	-	46	0	
LD 2	Arkansas	LRD	AR	67	162.0	-	110	0	519
LD 1	Arkansas	LRD	AR	67	142.0	-	2	0	

* Section 7 Flood Control Projects
Includes dead storage, conservation, water supply, power, irrigation, etc.

			RED RIVER BASIN						
Altus	N F Red	TD*	OK	46	1559.0	1562.0	141	21	
Tom Steed	W Otter Creek	TD*	OK	75	1411.0	1414.0	96	20	
Lake Kemp	Wichita R	TD*	TX	77	1144.0	1156.0	299	225	284
Waurika	Beaver Creek	TD	OK	78	951.4	962.5	203	140	290
Foss	Washita	TD*	OK	61	1652.0	1668.6	256	181	
Fort Cobb	Cobb Creek	TD*	OK	59	1342.0	1354.8	78	64	
Arbuckle	Rock Creek	TD*	OK	67	872.0	885.3	72	36	
Lake Texoma	Red	TD	TX/OK	45	617.3	640.0	2836	2660	299
Pat Mayse	Sanders Creek	TD	TX	68	451.0	460.5	124	65	310
Hugo	*Kiamichi R*	TD	OK	74	404.5	437.5	157	809	317
Pine Creek	Little R	TD	OK	69	443.5	480.0	78	388	322
Broken Bow	Mountain Fork	TD	OK	69	599.5	627.5	919	450	331
DeQueen	Rolling Fork	TD	AR**	77	437.0	473.5	35	101	342
Gillham	Cossatot	TD	AR**	76	502.0	569.0	33	189	348
Dierks	Saline R	TD	AR**	76	526.0	557.5	30	67	355
Millwood	Little R	TD	AR	66	259.2	287.0	207	1653	362
Wright Patman	Sulphur River	FWD	TX	56	220.0	259.5	143	2509	368
Lake O the Pines	Cypress Creek	FWD	TX	60	228.5	249.5	251	580	375
			NECHES RIVER BASIN						
Sam Rayburn	Angelina R	FWD	TX	65	164.4	173.0	2898	1009	380
B A Steinhagen	Neches R	FWD	TX	51	81.0	83.0	70	24	386
			TRINITY RIVER BASIN						
Benbrook	Clear Fork	FWD	TX	52	694.0	724.0	88	170	391
Lewisville	Elm Fork	FWD	TX	54	515.0	532.0	465	525	398
Grapevine	Denton Cr	FWD	TX	52	535.0	560.0	189	248	403
Lavon	East Fork	FWD	TX	77	492.0	503.5	457	277	408
Navarro Mills	Richland Cr	FWD	TX	68	424.5	443.0	63	149	414
Bardwell	Waxahachie Cr	FWD	TX	65	421.0	439.0	55	85	420
			SAN JACINTO RIVER BASIN						
Barker	Buffalo Bayou	GD	TX	45	-	107.0	0	207	426
Addicks	Buffalo Bayou	GD	TX	48	-	114.0	0	205	429
			BRAZOS RIVER BASIN						
Whitney	Brazos	FWD	TX	51	533.0	571.0	627	1372	432
Waco	Bosque	FWD	TX	65	455.0	500.0	153	574	438
Proctor	Leon R	FWD	TX	63	1162.0	1197.0	59	315	443
Belton	Leon R	FWD	TX	54	594.0	631.0	458	640	449
Stillhouse H	Lampasas R	FWD	TX	68	622.0	666.0	236	395	455
North Fork	N F San Gabriel	FWD	TX	79	791.0	834.0	37	93	461
Granger	San Gabriel R	FWD	TX	79	504.0	528.0	66	179	466
Somerville	Yegua Cr	FWD	TX	67	238.0	258.0	160	347	471
			COLORADO RIVER BASIN						
Twin Buttes	S&M Concho R	FWD*	TX	63	1940.2	1969.1	186	454	
O C Fisher	N Concho R	FWD	TX	52	1908.0	1938.5	119	277	478
Hords Cr	Hords Cr	FWD	TX	48	1900.0	1920.0	9	17	482
Marshall Ford	Colorado R	FWD*	TX	40	681.0	714.0	1172	780	
			GUADALUPE RIVER BASIN						
Canyon	Guadalupe R	FWD	TX	64	909.0	943.0	386	355	487
			RIO GRANDE BASIN						
Platoro	Conejos R	AD*	CO	51	10027.5	10034.0	54	6	
Abiquiu	Rio Chama	AD	NM	63	-	6283.5	0	568	492
Cochiti	Rio Grande	AD	NM	75	5321.45	5460.5	47	539	494
Galisteo	Galisteo Cr	AD	NM	70	-	5608.0	0	90	496
Jemez Canyon	Jemez R	AD	NM	53	5160.0	5232.0	2	104	498
Los Esteros	Pecos R	AD	NM	80	4776.5	4797.0	267	182	500
Sumner	Pecos R	AD*	NM	37	4261.0	4282.0	47	86	
Two Rivers	Rio Hondo	AD	NM	63	-	4032.0	0	168	502

** These projects transferred to Little Rock District 1 Oct 80.

ALPHABETICAL INDEX

SECTION IX

DETAILED PROJECT EVALUATIONS

BEAVER LAKE - INSTREAM FLOW PROBLEMS
AND NEEDS EVALUATION

1. Project Name: Beaver Lake

2. Project Location: Beaver Dam is located on the main stem of the White River at river mile 609.0, 9 miles northwest of Eureka Springs, Arkansas. There are 1,186 square miles of drainage area above the dam.

3. Type of Project:

a. General Category: Beaver is one of four multiple-purpose projects constructed in the upper White River Basin for flood control, hydroelectric power generation, municipal and industrial water supply, and other beneficial purposes. The project also offers excellent recreational opportunities. The other multiple-purpose projects in the upper White River Basin are Table Rock, Bull Shoals, and Norfork Lakes.

b. Pertinent Data:

	Elevation ft. m.s.l.	Area Acres	Storage Capacity 1,000 Ac-Ft	Storage Capacity Inches
Top of Flood Pool	1130.0	31,700	1951.5	30.8
Nominal Top of Power and Water Supply Pool, Top of Conservation Pool	1120.0[1]	28,220	1651.5	26.1
Nominal Bottom of Power Pool	1077.0[1]	15,540	726.8	11.5
Flood Control Storage	1130-1120[1]	3,480	300	4.7
Power & Water Supply Storage	1120-1077	12,680	924.7	14.6
Streambed	914.0			

[1]The top of the seasonal power pool will be elevation 1121.0 for the period 1 May to 1 October.

c. Outlets:

Type	No. & Size	Invert El. ft. m.s.l	Opening Size & Control	Maximum Discharge (cfs)[1] Top flood	Top conservation
Ogee Spillway	1 - 280' (Net)	1,093.0	7 - 40'x 37' Tainter Gates	251,000	- - -
Sluice	1 - 5'8"x 10'	937.9	2 - Hydraulic slide gates	5,370	5,240
Power Units	2 - 20.5' (dia)	982.0[2]	2 - Hoist gates	7,500	7,900
House Units	1 - 42"dia	980.5[2]			20

[1]Turbine discharges at rated capacity.
[2]Centerline elevation

d. Power Development:

Main generating units, number	2
Rated capacity, each unit, kW	56,000
Total capacity, kW	112,000

4. Water Management Operating Criteria:

a. Purposes: Beaver Lake is one of four multiple-purpose projects constructed in the upper White River Basin for the control of floods and the generation of hydroelectric power and other beneficial purposes.

b. Water-use Contracts: None

(1) Beaver Water District - 1960

(2) Carroll-Boone Water District - 1977

c. Interagency Agreements: None

d. Informal Commitments: The Corps, Southwestern Power Administration, and the Arkansas Game and Fish Commission have agreed that minimal daily power releases will be made for the trout fishery and flow maintenance based on air temperatures forecast by the National Weather Service (see Table 1) between 1 May and 30 September, normally and when otherwise required by unseasonable temperatures, turbidity, stagnation, or other similar intermittent problems. Storage for these releases is provided by a seasonal buffer zone between the flood control and power pools which also enhances power usage and recreation.

Special operations to enhance fish spawns in the White River lakes have been conducted based on Arkansas Game and Fish Commission or Missouri Department of Conservation recommendations for their urgent need. The first such special operation at Beaver Lake was conducted in 1978.

TABLE 1
Minimum Releases for Trout Fisheries and
Flow Maintenance

Air Temp (°F)	Beaver	Minimum Daily Flow (d.s.f.) Table Rock	Bull Shoals	Norfork	Greers Ferry
90° or below	85	100	250	145	115
91-95	125	140	375	218	150
96-104	165	175	500	290	175
105+	200	200	750	360	225

e. System Regulation Objectives: The overall regulation objective of the White River System is to reduce flood damages within the basin. While regulation of the system could tend in general to reduce the contribution of flood flow to the Mississippi River, it is not routinely possible to regulate for floods on the Mississippi because of the considerable length of crest travel times of major floods within the two systems.

Bull Shoals and Norfork releases are regulated for flood control to consider downstream flooding conditions and intervening flows between the dams and Newport, Arkansas (just downstream from the mouth of the Black River) with seasonally variable target stages at Newport as follows:

21 feet	1 December - 30 April
18 feet	1 May - 31 May
14 feet	1 June - 30 November

When flood control storage space is in use at Table Rock and/or Bull Shoals, Beaver releases are restricted to those required for firm power. Table Rock's power releases are kept at full capacity and may be supplemented by spillway releases until such time as the remaining flood control storage in Table Rock and Bull Shoals is equal. This occurs at approximate elevations 915 and 684 ft., m.s.l., respectively. After Bull Shoals and Table Rock's remaining flood control storage is approximate equal, releases from Table Rock are reduced to maintain approximately equal amounts of remaining storage in Table Rock and Bull Shoals, subject to firm power generation at Table Rock. After Table Rock and Bull Shoals are essentially evacuated, Beaver is evacuated with releases equal to the downstream channel capacity or minimum permissible releases from Bull Shoals.

The plan of regulation provides for prorating the permissible flood control releases between the Beaver-Table Rock-Bull Shoals system on the White River and the Norfork project on the North Fork River in accordance with the percent of flood control storage in use at the time.

TABLE 2
Beaver Lake Project - WQ Data[1]

	Sample Location			
Parameter	Upstream[2]	Upstream[3]	Lake[4]	Downstream[5]
Temperature(°C)	16	19.5	-[6]	7.5
Turbidity (JTU)	30	4.8	8.5	2.3
pH (SU)	7.4	7.6	7.7	7.5
Specific Conductance (micro Mho)	149	108	123	136
Dissolved Oxygen (mg/l)	8.1	8.0	-[6]	10.2
Nitrates & Nitrites (mg/l)	0.39	0.37	0.32	0.26
Phosphorous (mg/l)	0.09	0.05	0.06	0.04
Chloride (mg/l)	8.2	3.0	3.5	4.3
Sulfate (mg/l)	13.4	6.0	7.0	15.5
Fecal Coliform (#/100ml)	626	19	1	0
Iron (ug/l)	1,292	165	114	20
Manganese (ug/l)	188	50	24	20
Aluminum (ug/l)	400	165	126	80
Zinc (ug/l)	73	10	25	14

1 Mean values of up to 60 measurements at each station (1974 - 1979).
2 On White River near Goshen, approx. 412 sq. mi. drainage area.
3 At 4 stations on tributaries entering lake.
4 At 2 stations on the lake near the dam.
5 Near Eureka Springs just below the dam.
6 Omitted because of the wide range with depth and season.

5. Project Evaluation:

a. General: Table 2 summarizes pertinent water quality data obtained during the period from 1974 through 1979 on the White River near Goshen, on four tributaries entering the lake, in the lake near the dam (2 stations), and downstream below the dam. It contains mean values of up to 60 measurements taken at each station.

Waters in and released from Beaver Lake typify similar lakes in the White River Basin

In mid-summer the metalimnion sometimes has extremely high dissolved oxygen levels as shown in Figure 1. The high levels are thought to be the result of photosynthetic activity of algae suspended within that layer.

During the late summer and fall seasons, the lake stratifies and the hypolimnion becomes oxygen deficient (Figure 2).

b. Effects of Impoundment on Water Stored:

(1) Positive Effects: Turbidity on the White River entering Beaver Lake is quite high compared to the other tributaries entering the lake, but impoundment reduces turbidity in the lake and the releases downstream. Impoundment plays a part in the reduction in the amounts of iron, manganese, aluminum, and zinc moving in the river. Also, there are high fecal coliform counts entering the lake from point-discharge sources and heavy recreational use which die off in the lake. Impoundment and the release facilities allow for cold water releases to support small mouth bass and trout fisheries.

(2) Negative Effects: Additional degradation of the lake could occur with increased shoreline development, urbanization within the basin, and recreational activities. This degradation would probably take the form of increased loads of sediments, nutrients, organics, and heavy metals. Excessive nutrients and organic material could accelerate the process of eutrophication. Accumulation of toxic metals in the lake bottom sediment could adversely affect use of the lake as a water supply. Depletion of dissolved oxygen in the lower depths from mid-summer to early fall causes greater concentrations of iron, manganese, and other metals in the water which is mixed throughout the lake when stratification breaks up in late fall.

The U.S. Environmental Protection Agency's National Eutrophication Survey considers Beaver Lake mesotrophic. The limiting element in algal growth is phosphorous. However, there have been other studies done on the lake, and the general consensus is that Beaver has significant eutrophic potential. With the increase in development around the lake and the stimulated industrial growth, the lake should be checked for a shifting from its mesotrophic classification.

(3) Causes of Negative Effects: The Fayetteville-Springdale-Rogers area, which is largely within the Beaver Lake watershed, is developing rapidly, and this development results in greater pollutant loads to the lake.

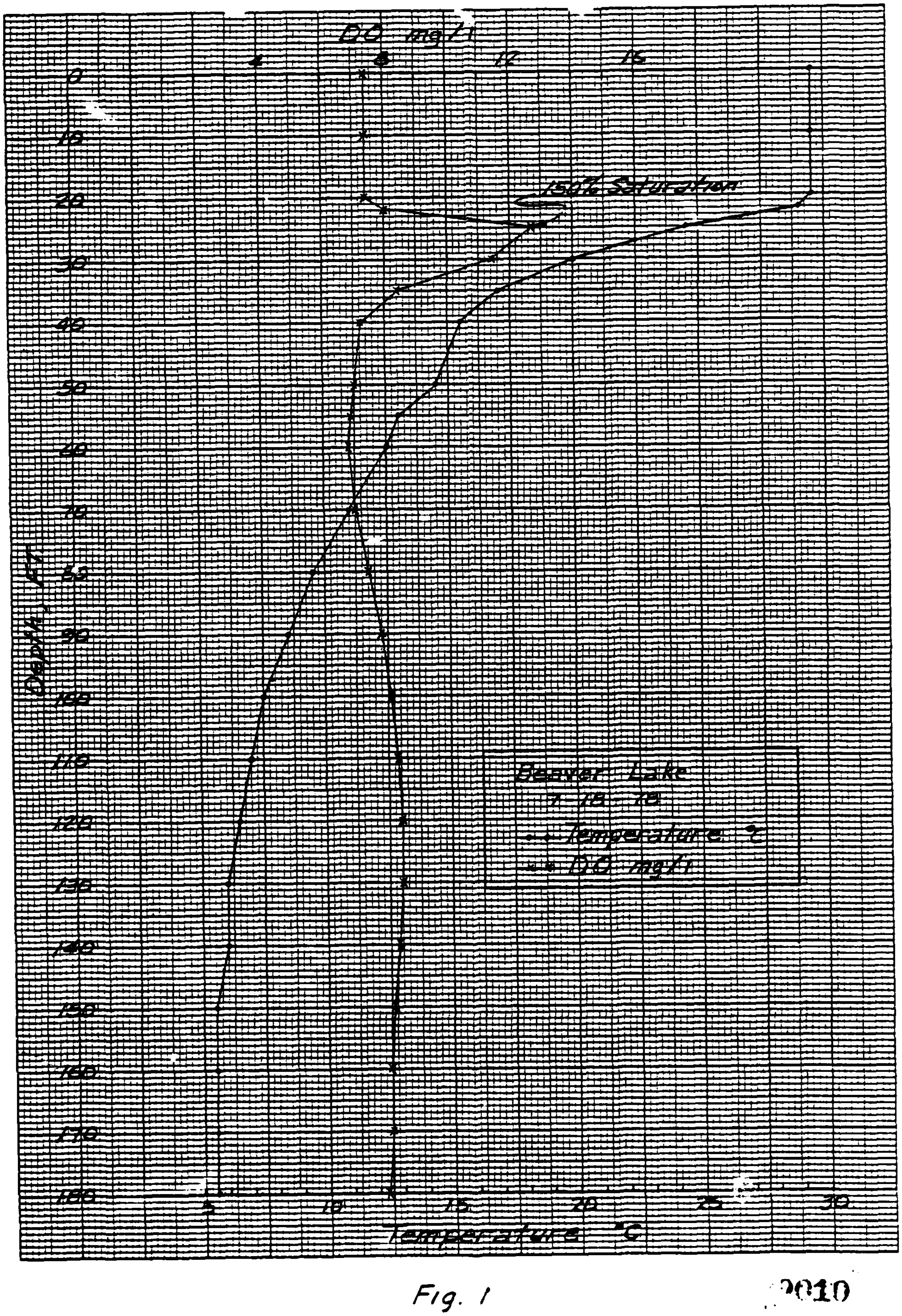


Fig. 1

2010

K•E 10 X 10 TO ½ INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A. 46 1323

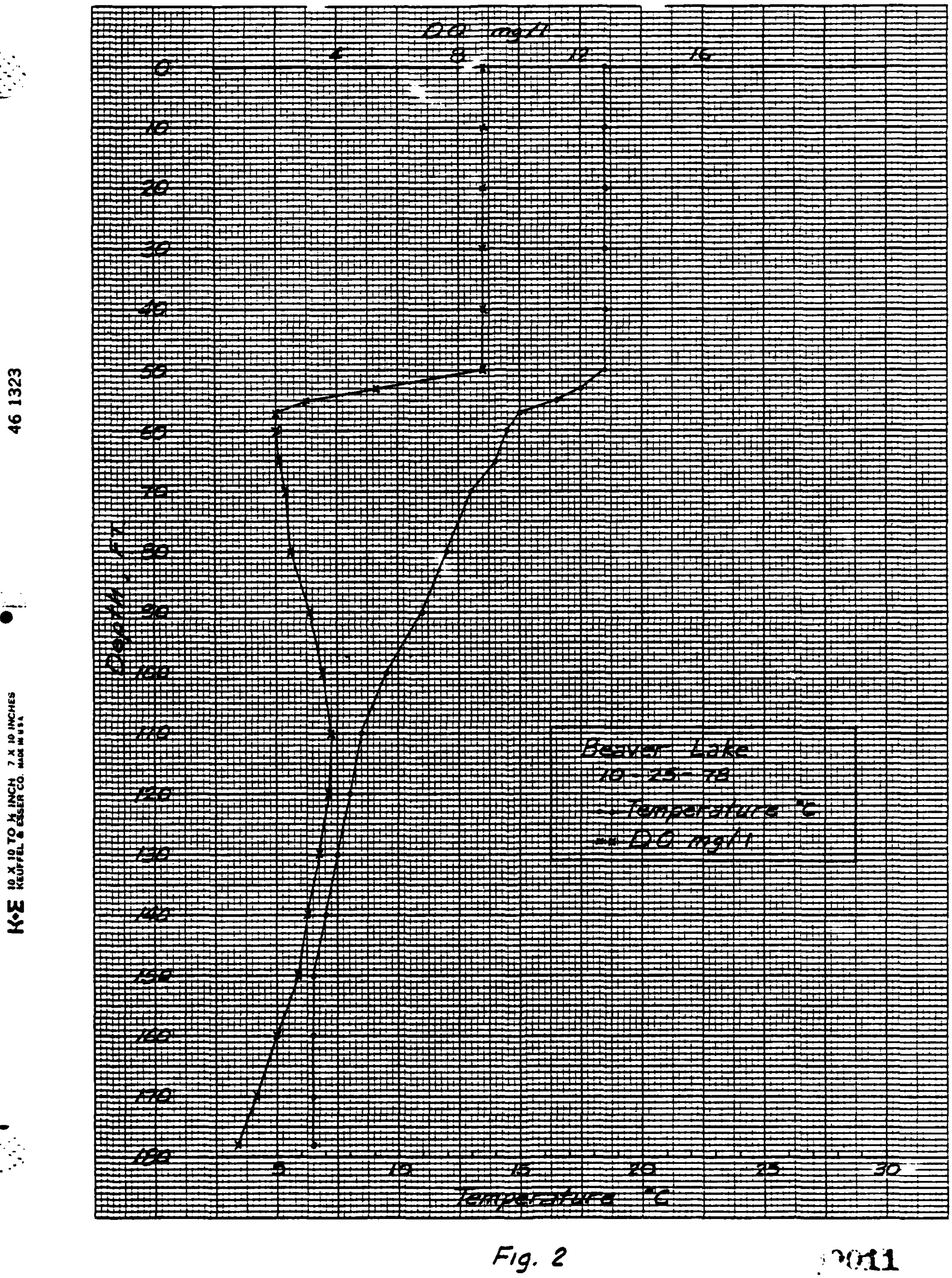

DO mg/l
4
8
12
16
Depth, FT
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
5
10
15
20
25
30
Temperature °C
Beaver Lake
10-25-78
Temperature °C
DO mg/l
46 1323
K•E 10 X 10 TO ½ INCH 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

Fig. 2

The poultry industry is very important in the area, and it contributes significant amounts of organic matter. The city of Fayetteville's sewage effluent has significant amounts of heavy metals from industry. The limestone geology around the lake is not suitable for the septic tanks associated with shoreline development. Lower depth depletion of oxygen is a result of stratification, which is caused by seasonal warming of the epilimnion.

c. Project Effects on Instream Flows:

(1) General: Figure 3 shows both the natural and regulated annual flow duration curves. Monthly discharge-duration curves for the project's natural and existing (regulated) flows at Beaver are shown in figures 4 through 27. These figures represent computer model simulations of mean daily flows for a period of record from October 1939 through September 1974.

(2) Positive Effects: The cold water releases have allowed the development of a popular trout fishery. The flood control feature of the project reduces the high flows and increases the duration of near bankfull flows in the short reach downstream of the dam. The minimum releases, combined with the station service unit releases and leakage, are significantly greater than preproject low flows.

(3) Negative Effects: Power generation releases during the late summer and fall frequently contain less than the 6 milligram per liter dissolved oxygen Arkansas water quality standard for small mouth bass or trout streams. This water, however, is reaerated somewhat at lower flows in the 4 to 5 miles of stream prior to entering Table Rock Lake.

(4) Causes of Negative Effects: The occasional release of oxygen deficient water is due to lake stratification and the level in the lake from which the water is withdrawn.

6. Constraints on Obtaining Instream Quantity and Quality Objectives:

a. Quantity: There have been significant conflicts between the in-pool recreation needs and the hydroelectric power generation objective of the project. The boat dock owners and recreational users of the lake want minimal lake level fluctuations, especially during the peak recreation period. While these interests seem to accept fluctuations due to flood control operations of the project, they oppose drawdowns due to power generation, especially during low inflow periods.

b. Quality: There has been some concern expressed by the Beaver Water District that power drawdowns during low inflow periods result in deteriorated water quality. This is primarily due to the intake location. During no-flow periods the more heavily polluted inflow accumulates near the intake until there is a rise to flush it on downstream.

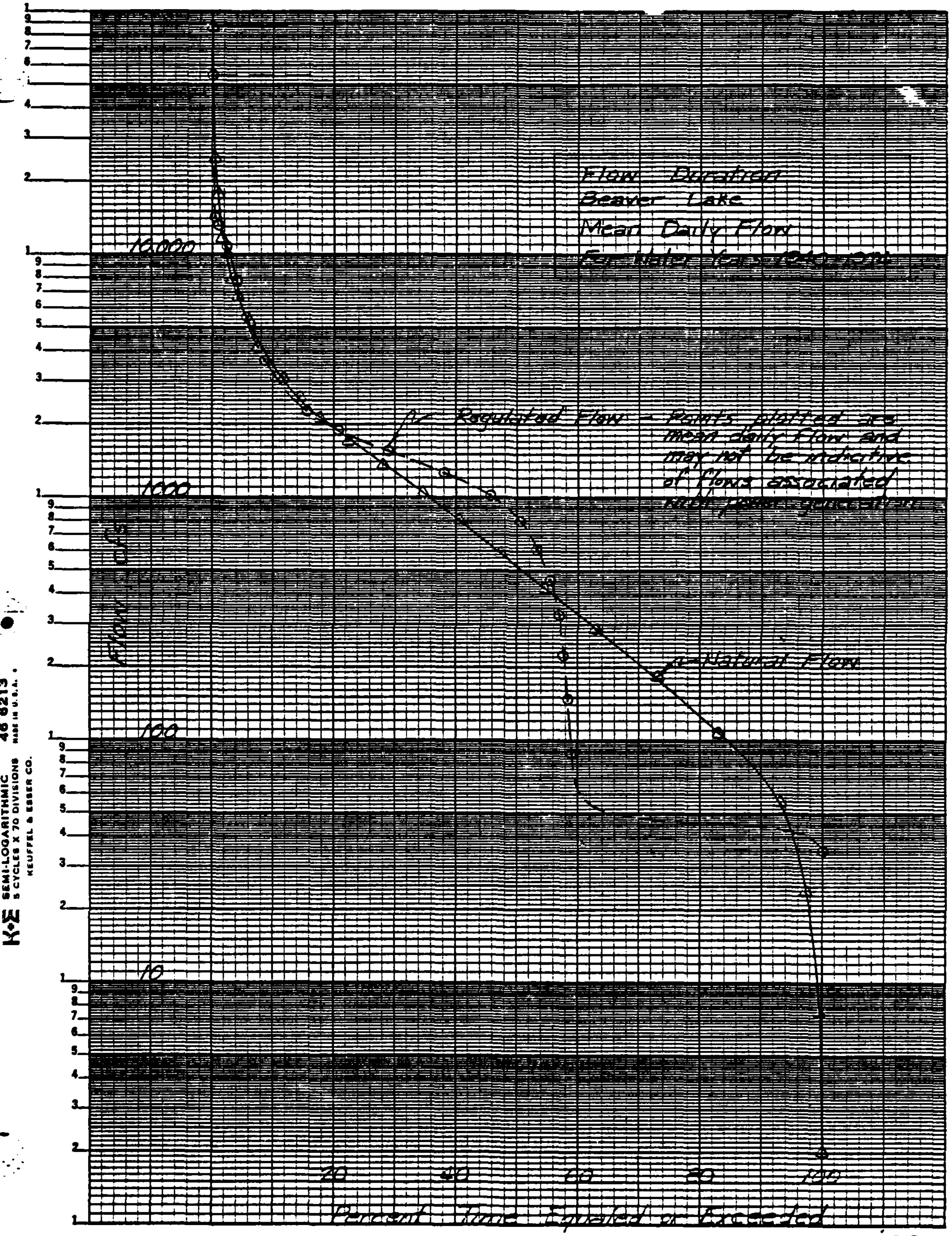

Flow Duration
Beaver Lake
Mean Daily Flow
Regulated Flow - Points plotted are mean daily flow and may not be indicative of flows associated with power generation
Natural Flow
Flow cfs
Percent Time Equaled or Exceeded
10,000
1000
100
10
20
40
60
80
100
K+E SEMI-LOGARITHMIC 46 6213
5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO.

Fig. 3

7. Alternatives:

a. Reservoir Regulation: The present Water Control Plan is generally considered adequate for downstream quantity needs, but alternative plans are being investigated as part of the White River Lakes Study.

b. Structural Modification: N/A

c. Storage Reallocation: N/A

d. Other: N/A

8. Actions Taken to Date: Instream flow needs have not been addressed thus far; however, studies are pending, as described in paragraph 9.

9. Planned Actions: Various alternative operating plans, including storage allocation changes, are being addressed in the White River Lakes Study. In addition, instream flow needs will be addressed and each alternative operating plan will be evaluated. This phase of the study is being closely coordinated with various fish and wildlife agencies. This study is scheduled for completion in 1983.

Bull Shoals Lake - Instream Flow Problems and Needs Evaluation

1. Project Name: Bull Shoals Lake.

2. Project Location: Bull Shoals Dam is located on the main stem of the White River at river mile 418.6, 7 miles north of Cotter, Marion County, Arkansas. There are 6,036 square miles of drainage area above the dam.

Water management control stations are located downstream at Flippin, Calico Rock, Batesville, Newport, and Georgetown, Arkansas. Newport is the principal regulating station for Bull Shoals, but local flooding or water quality problems may require shifts to the other stations.

3. Type of Project:

a. General Category: Bull Shoals is one of four multiple-purpose projects authorized and constructed in the upper White River Basin for the control of floods, generation of hydroelectric power, and other beneficial purposes. The project also offers excellent recreational opportunities. The other multiple-purpose projects in the upper White River Basin are Beaver, Table Rock, and Norfork Lakes.

b. Pertinent Data:

	Elevation ft. m.s.l.	Area Acres	Storage Capacity 1,000 Ac. ft.	Storage Capacity inches
Top of Flood Pool	695.0	71,240	5,408	16.8
Spillway Crest	667.0	52,510	3,682.5	11.4
Nominal Top of Power Pool, Top of Conservation Pool	654.0[1]	45,440	3,048	9.4
Nominal Bottom of Power Pool	628.5	33,800	2,045	6.4
Flood Control Storage	695-654[1]	-	2,360	7.4
Power Storage	654-628.5[1]	-	1,003	3.0
Streambed	450	-	-	-

[1]The top of the seasonal power pool will be elevation 655.0 on 1 May, 657.0 from 15 May to 15 June, and 656.0 from 15 July to 1 October.

c. Outlets:

Type	No. & Size	Invert El. ft. m.s.l.	Opening Size & Control	Maximum Discharge (c.f.s)[1] Top Flood	Top Conservation
Gated Ogee Spillway	1-680'(net)	667.0	17-40'x28' Tainter Gates	376,000	-
Sluice	16-4'x9'	477.0	32-Hydraulic Slide Gates	60,500	55,000
House Units	2-5' dia.	528.0[2]	60" Pivot Valve	-	200
Power Units					
-40 MW	4-18' dia.	526.4	8-23'-1"x18'-3"	8,800	10,600
-45 MW	4-18' dia.	526.4	Hoist Gates	10,200	11,800

[1]Turbine discharges at rated capacity.
[2]Centerline elevation.

d. Power Development:

Main Generating Units, number	8
Rated Capacity, each unit, kw	4 @ 40,000 4 @ 45,000
Total kw	340,000

4. Water Management Operating Criteria:

a. Purposes: Bull Shoals is one of four multiple-purpose projects constructed in the upper White River Basin for the control of floods, the generation of hydroelectric power, and other beneficial purposes.

b. Water Use Contracts. None

c. Interagency Agreements: None

d. Informal Commitments: The Corps, Southwestern Power Administration, and the Arkansas Game and Fish Commission have agreed that minimal daily power releases will be made for the White River Trout Fishery based on air temperatures forecast by the National Weather Service (see Table 1) between 1 May and 30 September, normally, and when otherwise required by unseasonable temperatures, turbidity, stagnation or other similar intermittent problems. In addition, a combined 3-day running average release of not less than 2,000 d.s.f. for Norfork and Bull Shoals Dams will be provided when the next day's air temperature in the area is forecast to be above 85°F. Storage for these releases is provided by a seasonal buffer zone between the flood control and power pools which also enhances power usage and recreation.

Special operations to enhance fish spawns in the White River lakes have been conducted based on Arkansas Game and Fish Commission or Missouri Department of Conservation recommendations for their urgent need. The first such special operation at Bull Shoals in May-June 1972 was marginally successful. None since have been required because of the pattern of high water in subsequent years.

TABLE 1
Minimum Releases for Trout Fisheries and
Flow Maintenance

Air Temp (°F)	Minimum Daily Flow (d.s.f.)				
	Beaver	Table Rock	Bull Shoals	Norfork	Greers Ferry
90° or below	85	100	250	145	115
91-95	125	140	375	218	150
96-104	165	175	500	290	175
105+	200	200	750	360	225

e. System Regulation Objectives: The overall regulation objective of the White River system is to reduce flood damages within the basin. While regulation of the system could tend in general to reduce the contribution of flood flow to the Mississippi River, it is not routinely possible to regulate for floods on the Mississippi because of the considerable length of crest travel times of major floods within the two systems.

Bull Shoals and Norfork releases are regulated for flood control to consider downstream flooding conditions and intervening flows between the dams and Newport, Arkansas, (just downstream from the mouth of the Black River) with seasonally variable target stages at Newport as follows:

21 feet	1 December - 30 April
18 feet	1 May - 31 May
14 feet	1 June - 30 November

When flood control storage space is in use at Table Rock and/or Bull Shoals, Beaver releases are restricted to those required for firm power. Table Rock's power releases are kept at full capacity and may be supplemented by spillway releases until such time as the remaining flood control storage in Table Rock and Bull Shoals is equal. This occurs at approximate elevations 915 and 684 ft., m.s.l., respectively. After Bull Shoals and Table Rock's remaining flood control storage is approximate equal, releases from Table Rock are reduced to maintain approximately equal amounts of remaining storage in Table Rock and Bull Shoals, subject to firm power generation at Table Rock. After Table Rock and Bull Shoals are essentially evacuated, Beaver is evacuated with releases equal to the downstream channel capacity or minimum permissible releases from Bull Shoals.

The plan of regulation provides for prorating the permissible flood control releases between the Beaver-Table Rock-Bull Shoals system on the White River and the Norfork project on the North Fork River in accordance with the percent of flood control storage in use at the time.

5. Project Evaluation:

a. General: Bull Shoals is one of five large White River Basin lakes which have basically similar water quality characteristics. These large deep lakes begin to stratify in late spring or early summer and remain stratified until late fall or early winter. Stratification in the lakes is very strong, with temperature differentials between the surface and bottom commonly exceeding 20°C in July. Figure 1 is a typical late fall stratification pattern in Bull Shoals Lake. It shows that dissolved oxygen remains sharply stratified even though the thermal stratification has weakened considerably since summer. Bull Shoals Lake has a somewhat unusual metalimnic dissolved oxygen pattern during the summer, as shown in Figure 2. The extremely high levels of dissolved oxygen are thought to be the result of photosynthetic activity by algae that settle within the metalimnion.

The Arkansas Game and Fish Commission and the U.S. Fish and Wildlife Service have established a cold water trout fishery in the White River from Bull Shoals Dam downstream to the vicinity of Guion, Arkansas. The Arkansas water quality standard for temperature in a trout stream is 68°F. The releases from Bull Shoals range from 38 to 55°F. Warming occurs downstream, however, and releases as described in paragraph 4d are necessary to meet the SWD approved objective of maintaining water temperatures below 75°F at Sylamore. At times, large warm water inflows from Crooked Creek, Buffalo River, and other downstream tributaries may require special release schedules to alleviate adverse effects on the White River trout fishery.

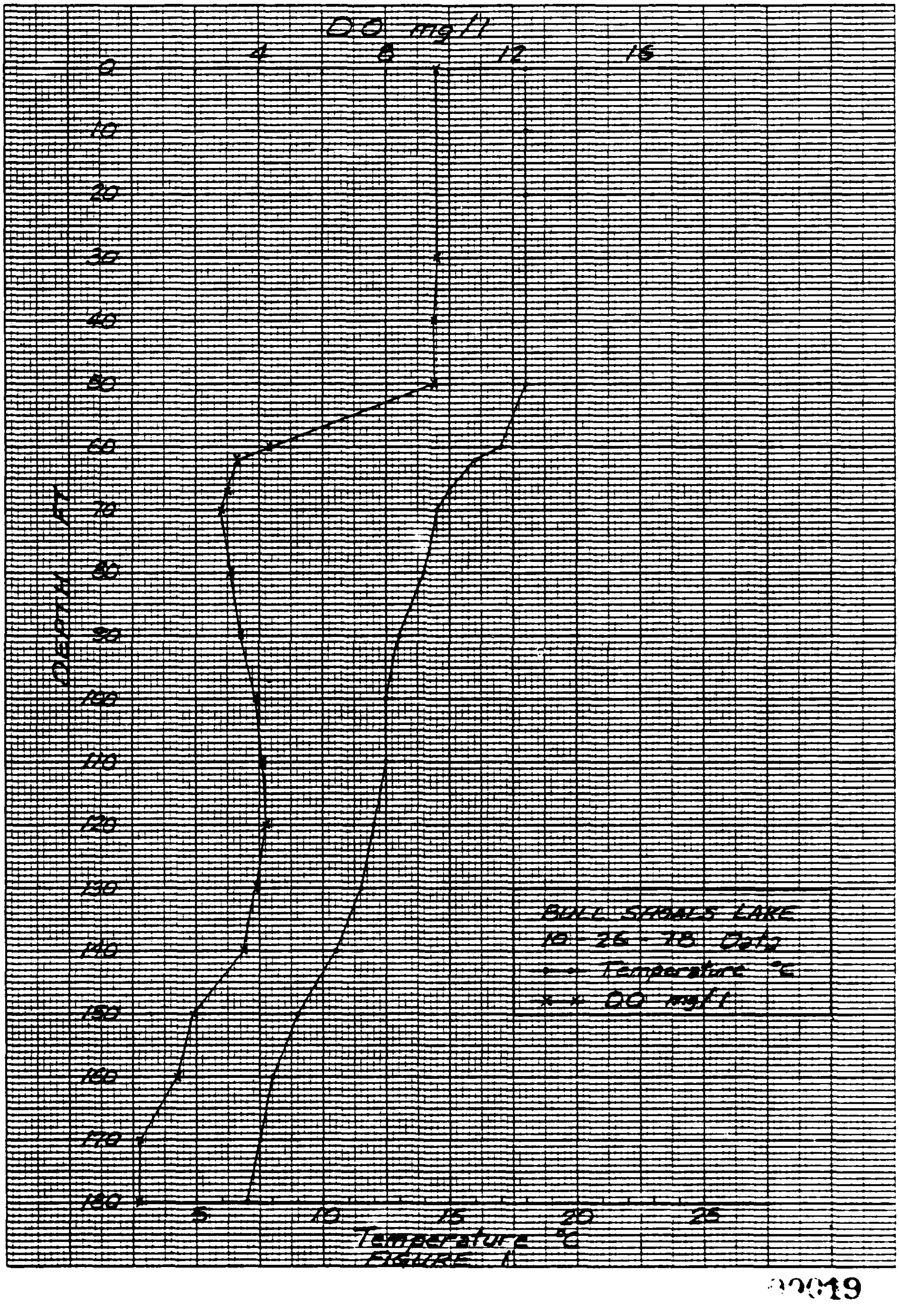
Table 2 summarizes certain water quality data obtained during the period 1975 to 1979 upstream near Forsyth, within the lake (10 stations), and downstream near the dam. It contains mean values of up to 15 measurements at each station.

On the basis of nutrient concentrations and other data and field observations, Bull Shoals Lake was classified as mesotrophic by EPA's National Eutrophication Survey. Phosphorus appears to be the limiting nutrient. Almost 85 percent of the phosphorus load to the lake comes from the upstream lakes, Beaver, Table Rock and Taneycomo (White River), during a typical year.

b. Effects of Impoundment on Water Stored:

(1) Positive Effects: All of the White River lakes have basically the same effects on the inflows. The White River has low levels of solids, turbidity, and color, and these parameters are reduced even more by impoundment. Particulate forms of iron and manganese settle out in the lakes. The data indicate a slight decrease in the concentrations of nutrients entering Bull Shoals Lake. These trapped nutrients normally accumulate in the bottom sediments. Coliform bacteria entering the lakes die off.

(2) Negative Effects: During the latter stages of stratification, the oxygen in lower depths in the hypolimnion is depleted to extremely low values with the formation of a reducing environment. Under this environment objectionable compounds such as hydrogen sulfide may develop, and the leaching rate of constituents such as iron and manganese will be increased.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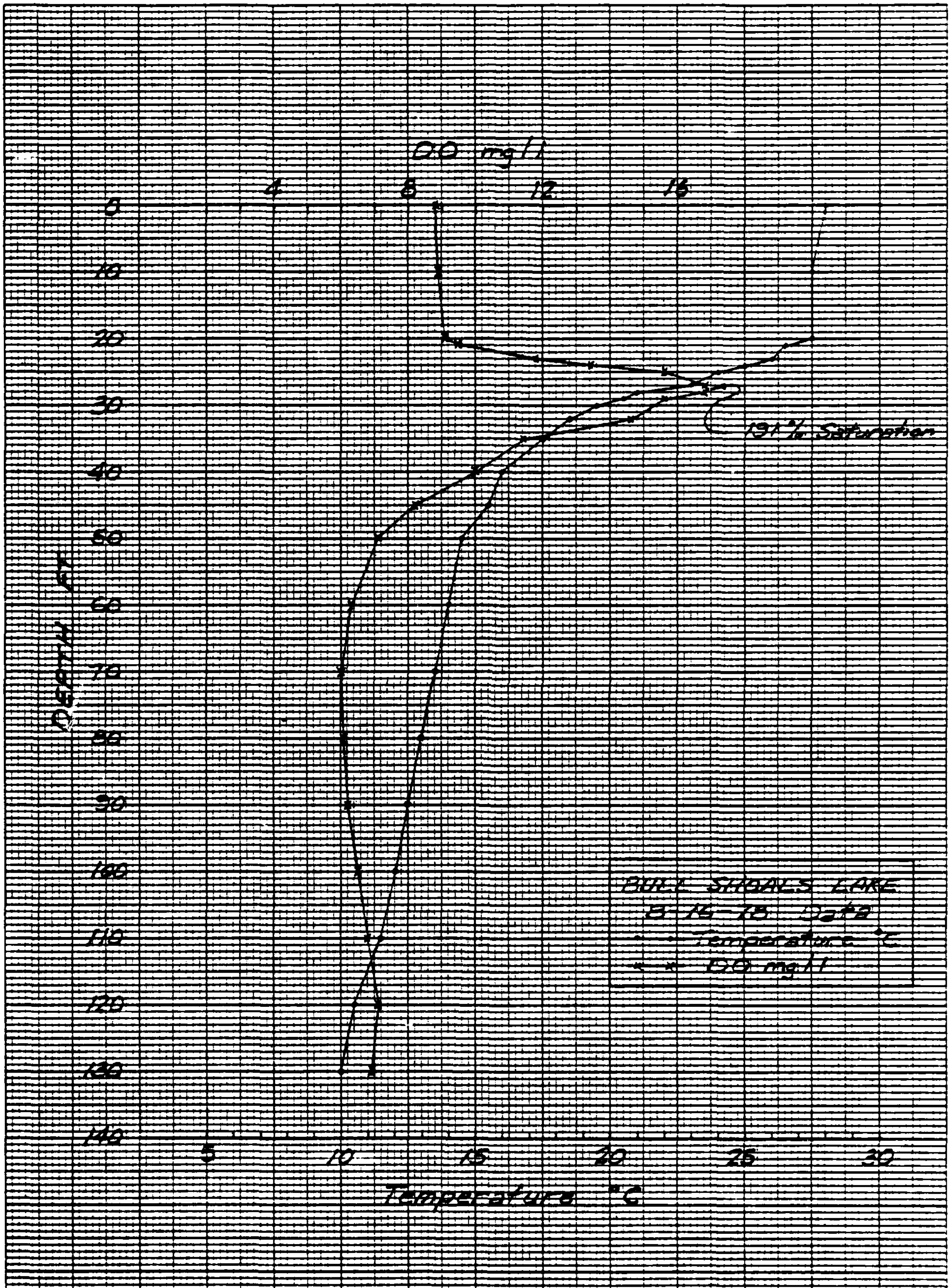
8
12
16
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
DEPTH FT
5
10
15
20
25
Temperature °C
BULL SHOALS LAKE
10-26-78 Data
Temperature °C
DO mg/l

FIGURE 1



DO mg/l
4
8
12
16
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
DEPTH FT
131% Saturation
BULL SHOALS LAKE
8-16-78 Data
Temperature °C
DO mg/l
5
10
15
20
25
30
Temperature °C

FIGURE 2

TABLE 2
Bull Shoals Lake Project - WQ Data[1]

Parameter	Sample Location		
	Upstream[2]	Lake[3]	Downstream[4]
Temperature (°C)	12	-(5)	7.5
Turbidity (JTU)	1.2	0.7	0.5
Dissolved Oxygen (mg/l)	8.8	-(5)	9.0
Iron (ug/l)	50	20	10
Manganese (ug/l)	40	15	5
Fecal Coliform (#/100 ml)	18	0	0
Nitrates + Nitrites (mg/l N)	0.4	0.3	0.3
Phosphorus (mg/l)	0.02	0.01	0.01
pH (SU)	8.0	8.0	8.0
Sulfates (mg/l)	6.8	11	12
Hardness (mg/l $CaCo_3$)	145	145	

[1]Mean values of up to 15 measurements at each station.
[2]Near Forsyth.
[3]At 10 stations on the lake.
[4]Near Bull Shoals below the dam.
[5]Omitted because of the wide range with both depth and season.

(3) Cause of Negative Effects: Stratification results from the seasonal warming of the epilimnion. The depletion of oxygen in the hypolimnion results from the B.O.D. and/or C.O.D. of the water trapped below the metalimnion.

c. Project Effects on Instream Flows:

(1) General: Discharge-duration curves for the project's natural and regulated (existing) flow at the control point at Flippin are shown in Figures 3 through 27. The flows represented in these figures are the results of a computer model simulation of mean daily flows for a period of record from October 1939 through September 1974. Figure 3 shows both the natural and regulated annual flow duration curves. Monthly flow durations for existing and natural conditions are shown in Figures 4 through 15 and 16 through 27, respectively.

(2) Positive Effects: The cold water releases have allowed the development of a very popular trout fishery. The flood control operation reduces the high flows and the subsequent flood releases increase the duration of flows around bank full downstream of the dam. Normal power releases provide more than adequate flows for most uses downstream from the dam. During extended periods of no generation (optimum), conditions for flyfishing exist in the tailwaters of the dam.

(3) Negative Effects: Occasionally releases are deficient in dissolved oxygen, but they quickly reaerate downstream as the water flows over natural shoals. Creation of the artificial cold water fishery resulted in a "transition zone" in which the water is too warm for trout and too cold for many warm water species. Depending on air temperatures and volume of releases, this zone extends from about Guion or Batesville on downstream to the confluence with the Black River. Problems have occurred in the past during warm weather 3-day weekends such as Memorial Day, July 4th, and Labor Day or other extended periods when there were insufficient power releases to maintain proper water temperatures downstream. Power demands often decrease over these periods, so there may be minimal or no generation releases. With minimal releases and high ambient air temperatures, the White River warms to a point that may endanger trout. The most critical stretch of the river influenced by Bull Shoals only is just upstream of the White River's confluence with the North Fork River. Below that confluence Norfork Lake releases also influence the water temperature and discharge. A related negative effect (depending on outlook) is the difficulty of recreational navigation and float fishing over shoals during minimum flow periods. At least 1 foot depths over shoals are considered desirable for those purposes. Evacuation of stored floodwaters may prevent planting or may damage crops on low-lying agricultural lands and releases over an extended period may damage commercial timber and timber in the game refuge on the lower White River. Conversely, delayed or extended evacuations may increase the chances of a damaging spill in the event of an unseasonal flood. Minimal power releases provide insufficient depths for navigation on the lower White River during periods of low flows from the uncontrolled area downstream from Bull Shoals.

(4) Causes of Negative Effects: The occasional release of oxygen deficient water is due to lake stratification and the level in the lake from which the water is withdrawn. The warming of the water downstream is a natural process compounded at times by warm water inflow from downstream tributaries such as Crooked Creek, Buffalo River, and Sylamore Creek. It is a problem that has evolved as the artificial trout fishery has developed since project construction.

d. Project Effects on System Regulation: As the furthest downstream project on the main stem White River, Bull Shoals has a significant effect on regulation of flood flows for the overall White River system. As described in paragraph 4e, Bull Shoals and Norfork Lakes are the primary controls on flow conditions in the lower White River Basin.

6. Constraints on Obtaining Instream Quantity and Quality Objectives:

a. Quantity: There have been conflicts regarding the quantity and timing of flood releases from Bull Shoals and Norfork Lakes that have led to deviations from the normal regulating plan. For example, evacuation of floodwaters has been delayed or prolonged by lowering downstream regulating stages to allow drainage from low agricultural lands to permit crops to be planted on such lands in time to allow them to mature. Power releases vary significantly depending on generation demands. Some fishery interests contend that larger continuous releases should be made to enhance float fishing while others (mostly flyfishermen) favor low continuous releases to enhance bank fishing and wading. Both groups desire no peaking power operations (i.e., producing a minimum daily release by generation of 1, 2, 3, etc., hours at rated capacity). However, at present there is no feasible way to produce an economical way to market the power produced by a continuous operation.

b. Quality: The need to release water on a daily basis during hot weather to avoid fish kills usually conflicts with the optimum pattern of power generation as necessary to meet peak load demands on the system.

7. Alternatives:

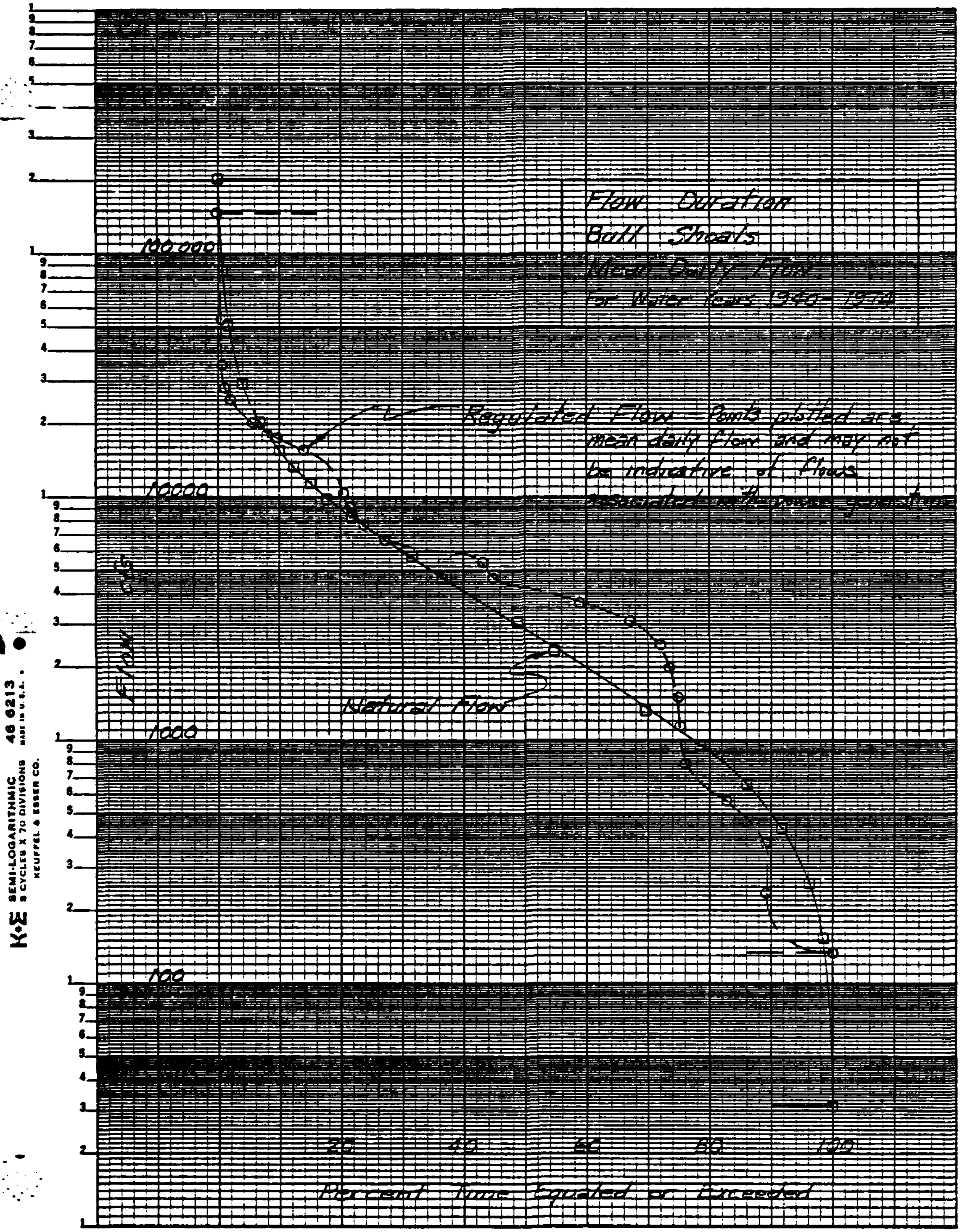
a. Reservoir Regulation: The present regulation plan is generally considered adequate for downstream quantity needs, but alternative plans are being investigated as part of the White River Lakes Study. Water quality problems associated with the current regulation plan will be addressed in that study and alternative plans will be developed and evaluated.

b. Structural Modification: Structural modifications are not considered applicable since problems can be ameliorated through operational modifications.

c. Storage Reallocation: Reallocation of storage is being addressed in the White River Lakes Study described in paragraph 8.

8. Actions Taken to Date: In-stream flow needs have not been addressed thus far; however, studies are pending, as described in paragraph 9 below.

9. Planned Actions: Various alternative operating plans, including storage allocation, are being addressed in the White River Lakes Study. In addition, in-stream flow needs will be addressed and each alternative operating plan will be evaluated. This phase of the study is being closely coordinated with various fish and wildlife agencies. For FY 81, $65,000 has been identified for in-stream flow needs studies. The study is now scheduled for completion in FY 83.



Flow Duration
Bull Shoals
Mean Daily Flow
for Water Years 1940-1974
Regulated Flow - Points plotted are mean daily flow and may not be indicative of flows associated with power operation
Natural Flow
100,000
10000
1000
100
Flow cfs
20
40
60
80
100
Percent Time Equaled or Exceeded
SEMI-LOGARITHMIC 46 6213
5 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.

Fig. 3.

NORFORK LAKE - Instream Flow Problems and Needs Evaluation

1. Project Name: Norfork Lake

2. Project Location: Norfork Dam is located on North Fork River, at river mile 4.8, 4 miles northeast of Norfork, Arkansas. The lake lies almost entirely in Baxter County, Arkansas. There are 1,806 square miles of drainage area above the dam of which 1,303 square miles are in Missouri. Water management control stations are located downstream at Calico Rock, Batesville, Newport, and Georgetown, Arkansas. Newport is the principal regulating station for Norfork, but local flooding or water quality problems may require shifts to the other stations.

3. Type of Project.

a. General Category: Norfork is one of four multiple-purpose projects constructed in the upper White River Basin for flood control, generation of hydroelectric power, and other beneficial purposes. The project also offers excellent recreational opportunities and provides municipal and industrial water supply to the city of Mountain Home.

b. Pertinent Data:

	Elevation ft. m.s.l.	Area Acres	Storage Capacity 1,000 ac-ft	inches
Top of Flood Pool	580.0	30,700	1,983.0	20.6
Nominal Top of Power Pool, Top of Conservation Pool	552.0 (1)	21,990	1,251.2	13.0
Bottom of Power Pool	510.0	12,300	544.2	5.7
Flood Control Storage	580-552 (1)	8,710	731.8	7.6
Power Storage	552-510.0 (1)	9,610	707.0	7.3
Stream Bed	374.0			

(1) The top of the seasonal power pool will be elevation 553.0 on 1 May, 555.0 from 15 May to 15 June, and 554.0 from 15 July to 1 October.

c. Outlets:

Type	No. & Size	Invert El. ft. m.s.l.	Opening Size & Control	Maximum Discharge (cfs) Top Flood	Top Conservation
Ogee Spillway	1 - 480' (net total)	552.0	12 - 40' x 28' Tainter Gates	270,000	---
Sluice	11 - 4'x6'	395.0	22 - hydraulic sliding gates	25,000	23,300
House Units	1 - 3' dia	423.0	Gate valve		20 (1)
Power Units	2 - 18' dia	438.8	2 18'-3" x 23'-1" hoist gate	4,700 (2)	5,400 (2)
Fish Hatchery	1-24" dia (3)	423.0			33
	1-14" dia	423.0			8

(1) Average daily use.
(2) At rated capacity.
(3) Reduced from the 36" diameter intake.

d. Power Development:

Power Units:		
Main Generating Units, number		2
Rated Capacity each unit, kw		40,275
Total	kw	80,550

4. Water Management Operating Criteria:

a. Purposes: Norfork is one of four multiple-purpose projects constructed in the upper White River Basin for the control of floods and the generation of hydroelectric power and other beneficial purposes.

b. Water Use Contracts. Operational - Water and Sewer Improvement District No. 3; 2,400 acre-feet of storage, 1967.

c. Interagency Agreements: None.

d. Informal Commitments: The Corps, Southwestern Power Administration, and the Arkansas Game and Fish Commission have agreed that minimal daily power releases will be made for the trout fishery and flow maintenance based on air temperatures forecast by the National Weather Service (see Table 1) between 1 May and 30 September, normally, and when otherwise required by unseasonable temperatures, turbidity, stagnation, or other similar intermittent problems.

In addition, a combined 3-day running average release of not less than 2,000 d.s.f. for Norfork and Bull Shoals Dams will be provided when the next day's air temperature in the area is forecast to be above 85°F. Storage for these releases is provided by a seasonal buffer zone between the flood control and power pools which also enhances power usage and recreation.

Special operations to enhance fish spawns in the other White River lakes have been conducted based on Arkansas Game and Fish Commission or Missouri Department of Conservation recommendations for their urgent need. None have been requested at Norfork Lake to date.

TABLE 1
Minimum Releases for Trout Fisheries and
Flow Maintenance

	Minimum Daily Flow (d.s.f.)				
Air Temp (°F)	Beaver	Table Rock	Bull Shoals	Norfork	Greers Ferry
90° or below	85	100	250	145	115
91-95	125	140	375	218	150
96-104	165	175	500	290	175
105+	200	200	750	360	225

e. System Regulation Objectives: The overall regulation objective of the White River system is to reduce flood damages within the basin. While regulation of the system could, in general, tend to reduce the contribution of flood flow to the Mississippi River, it is not routinely possible to regulate for floods on the Mississippi because of the considerable length of crest travel times of major floods within the two systems.

Bull Shoals and Norfork releases are regulated for flood control to consider downstream flooding conditions and intervening flows between the dams and Newport, Arkansas (just downstream from the mouth of the Black River) with seasonally variable target stages at Newport as follows:

21 feet	1 December - 30 April
18 feet	1 May - 31 May
14 feet	1 June - 30 November

The plan of regulation provides for prorating the permissible flood control releases between the Beaver-Table Rock-Bull Shoals system on the White River and the Norfork project on the North Fork River in accordance with the percent of flood control storage in use at the time.

5. Project Evaluation:

a. General: Norfork is one of five large White River Basin lakes which have basically similar water quality characteristics. These large deep lakes begin to stratify in late spring or early summer and remain stratified until late fall or early winter. Stratification in the lakes is very strong, with temperature differentials between the surface and bottom commonly exceeding 20°C in July. Figure 1 is a typical fall stratification pattern in Norfork Lake. The lake is similar to Bull Shoals in that it sometimes has an unusual metalimnic dissolved oxygen pattern during the summer, as shown in Figure 2. The extremely high levels of dissolved oxygen are thought to be the result of photosynthetic activity by algae that settle within the metalimnion.

The Arkansas Game and Fish Commission and the U.S. Fish and Wildlife Service have established a cold water trout fishery in the White River from Bull Shoals Dam downstream to the vicinity of Guion, Arkansas, and in the North Fork River from Norfork Dam to the mouth. The Arkansas water quality standard for temperature in a trout stream is 68°F. The releases from Norfork range from 38 to 59°F. Warming occurs downstream, however, and releases as described in paragraph 4d are necessary to meet the SWD approved objective of maintaining water temperatures below 75°F at Sylamore. At times, large warm water inflows from Crooked Creek, Buffalo River, and other tributaries may require special release schedules to alleviate adverse effects on the White River fishery.

Table 2 summarizes pertinent water quality data obtained during the period 1975 through 1980 on four tributaries entering the lake, within the lake (3 stations), and downstream below the dam. It contains mean values of up to 40 measurements taken at each location.

TABLE 2

Norfork Lake - WQ Data(1)

Parameter	Sample Location		
	Upstream(2)	Lake(3)	Downstream(4)
Temperature (°C)	15	-(5)	9.5
Turbidity (JTV)	3.5	1.1	1.0
PH (SV)	8.0	7.9	8.0
Dissolved Oxygen (mg/l)	10.0	-(5)	10.0
Nitrates & Nitrites (mg/l N)	.34	.35	.34
Phosphorous (mg/l)	.04	.04	.09
Fecal Coliform (2/100ml)	13	0	0
Iron (ug/l)	100	60	30
Manganese (ug/l)	60	50	50

(1)Mean values of up to 40 measurements at each station (1975-1980).
(2)At 4 stations on tributaries entering the lake.
(3)At 3 stations on the lake.
(4)Near Ellis, Arkansas, below the dam.
(5)Omitted because of the wide range with both depth and season.

b. Effects of Impoundment on Water Stored:

(1) Positive Effects: Turbidity is low in the North Fork River and it is reduced by impoundment as seen in Table 2. Impoundment also reduces the concentrations of iron and manganese moving in the river. Fecal coliforms entering the lake from point discharge sources on tributaries or on the lake die off in the lake. Stratification of the impounded water results in sufficient cold water in the lower depths of the lake to support a trout fishery downstream.

(2) Negative Effects: A National Fish Hatchery (NFH) is located just downstream from the dam which draws water from Norfork Lake through a 36-inch pipe reduced to 24 inches and/or a 14-inch pipe at elevation 423.0 ft. In 1979, the NFH had a serious fish kill (600,000 trout) from 24 October until 30 November 1979. After many water quality and autopsy tests were completed, it was determined that the high mortalities were caused by the induction of heavy metals (iron-manganese) into the water supply intake. Since the data in Table 2 do not reveal high concentration of iron and manganese in the inflow and in the lake, high concentrations may be present on the lake bottom due to natural sedimentation processes. Depletion of dissolved oxygen in the lower depths from mid-summer through fall (see Figures 1 and 2) allows iron and manganese to go into solution more readily. When stratification breaks up in late fall or early winter, these metals are mixed throughout the depths of the lake.

(3) Causes of Negative Effects: Stratification is primarily the result of seasonal changes in temperature. The quality of water withdrawn by the NFH is determined by the level in the lake from which water is withdrawn.

c. Project Effects on Instream Flows:

(1) General: Discharge-duration curves for the project's natural and existing (regulated) flows at Norfork are shown in Figures 3 through 27. These figures represent a computer model simulation of mean daily flows for a period of record from October 1939 through September 1974. Figure 3 shows both the natural and existing annual flow duration curves. Monthly flow durations for existing and natural conditions are shown in Figures 4 through 15 and 16 through 27, respectively.

The minimum Norfork and Bull Shoals combined 3-day running average release shall not be less than 2,000 d.s.f. when the next day's forecasted air temperature in the area is above 85°F as determined by the National Weather Service, Little Rock, Arkansas.

(2) Positive Effects: The cold power releases have allowed the development of a very popular trout fishery. The flood control feature of the project reduces the high flows and subsequent flood control and/or power releases in conjunction with similar releases from Bull Shoals may increase the duration of White River flows around bank full downstream of the dam. During periods of no generation, conditions for flyfishing exist in the tailwaters of the dam.

(3) Negative Effects: Occasionally releases are deficient in dissolved oxygen, but they quickly reaerate downstream as the water flows over natural shoals. Creation of the artificial cold water fishery resulted in a "transition zone" on the White River in which the water is too warm for trout and too cold for many warm water species. The zone extends from Guion to the mouth of the Black River. Warm water problems have occurred in the past during hot 3-day weekends such as Memorial Day, July 4th, and Labor Day or other similar extended periods when there were insufficient power releases to maintain proper water temperatures downstream. Power demands often decrease over these periods, so there may be minimal or no generation releases. With minimal releases and high ambient air temperatures, the White River warms to a point that may endanger trout. Evacuation of stored floodwaters may prevent planting or may damage crops on low-lying agricultural lands, and releases over an extended period may damage commercial timber and timber in the Wildlife Refuge downstream on the Lower White River. Conversely, delayed or extended evacuations may increase the chances of a damaging spill in the event of an unseasonal flood.

(4) Causes of Negative Effects: The occasional release of oxygen deficient water is due to lake stratification and the level in the lake from which the water is withdrawn. The warming of the water downstream is a natural process compounded at times by warm water inflow from downstream White River tributaries such as Crooked Creek, Buffalo River, and Sylamore Creek. It is a problem that has evolved as the artificial trout fishery has developed since project construction.

d. Project Effects on System Regulation. As described in paragraph 4e, Norfork and Bull Shoals Lakes are the primary controls on flow conditions in the lower White River Basin. Norfork is also critical for helping maintain proper water temperatures for the White River Trout Fishery between Bull Shoals Dam and Guion, Arkansas.

6. Constraints on Obtaining Instream Quantity and Quality Objectives:

a. Quantity: There have been conflicts regarding the quantity and timing of flood releases from Bull Shoals and Norfork Lakes that have led to deviations from the normal regulating plan. For example, evacuation of floodwaters has been delayed or prolonged by lowering downstream regulating stages to allow drainage from low agricultural lands to permit crops to be planted on such lands in time to allow them to mature. Power releases vary significantly depending on generation demands. Some fishery interests contend that larger continuous releases should be made to enhance float fishing while others (mostly flyfishermen) favor low continuous releases to enhance bank fishing and wading. Both interests desire no peaking power operations (i.e., producing a minimum daily release by generation of 1, 2, 3, etc., hours at rated capacity). However, at present there is no feasible way to market the power produced by a continuous operation.

b. Quality: The need to release water on a daily basis during hot weather to avoid fish kills usually conflicts with the optimum pattern of power generation as necessary to meet peak load demands on the system.

7. Alternatives:

a. Reservoir Regulation: The present regulation plan, although generally adequate for downstream needs, is being reevaluated as a part of the studies described in paragraph 8.

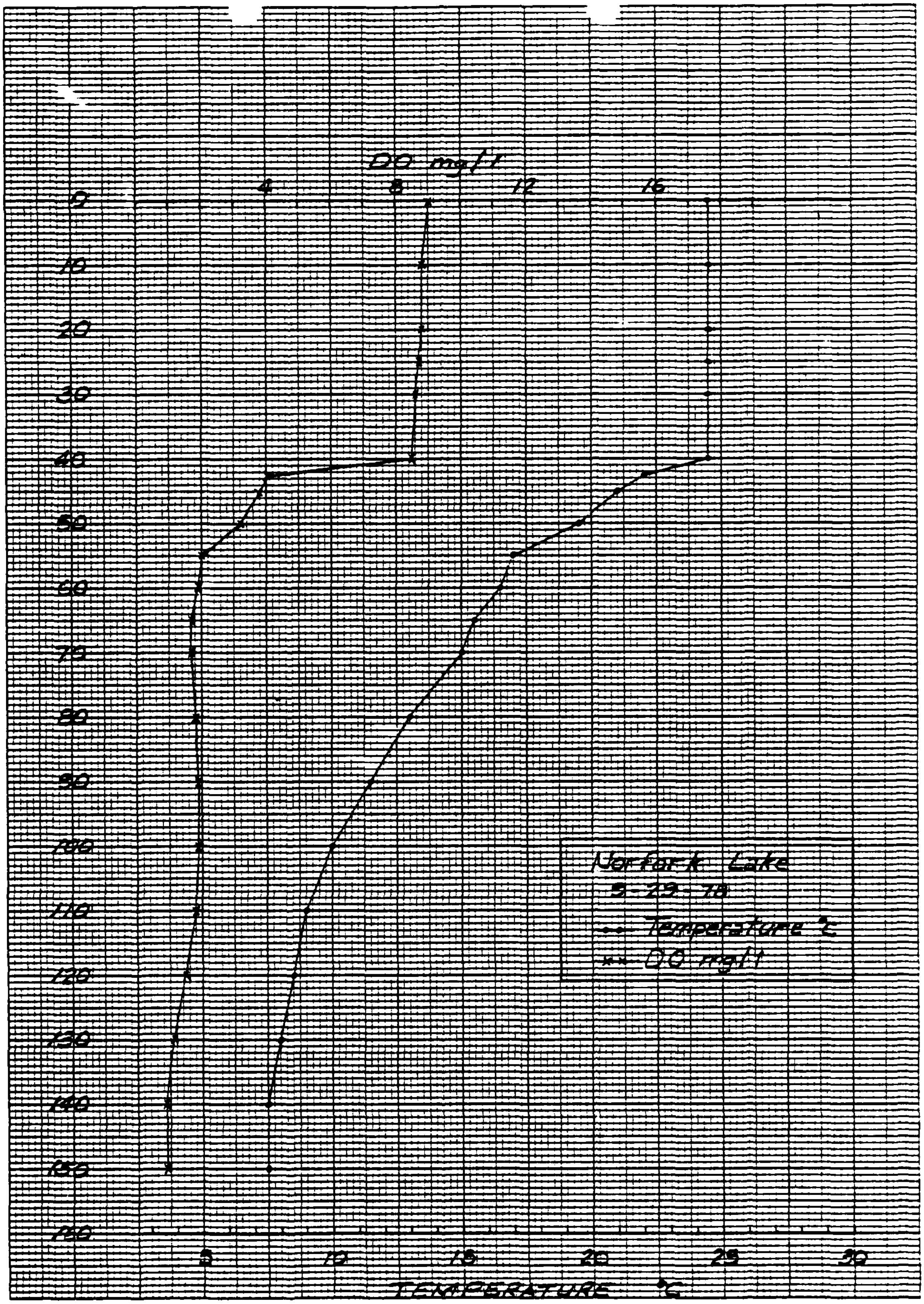
b. Structural Modification: Planning is underway to modify the NFH water supply intake to provide multi-level withdrawal capability.

c. Storage Reallocation: To the extent economically feasible, storage might be reallocated to fish and wildlife purposes to satisfy some of those needs downstream.

d. Other: NA

8. Actions Taken to Date: Various alternative operating plans, including storage allocations, are being addressed in the White River Lakes Study. The addition of power units to the existing project is being addressed in the Norfork Units 3 and 4 study project.

9. Planned Actions: Part of the White River Lakes study will involve evaluating alternative release schemes for Bull Shoals and Norfork to minimize adverse water temperatures downstream and to evaluate the need for releases for recreational boating, etc. The Norfork Units 3 and 4 study will include determining the effects of the pumpback units and afterbay on Norfork Lake, the North Fork River, and the White River.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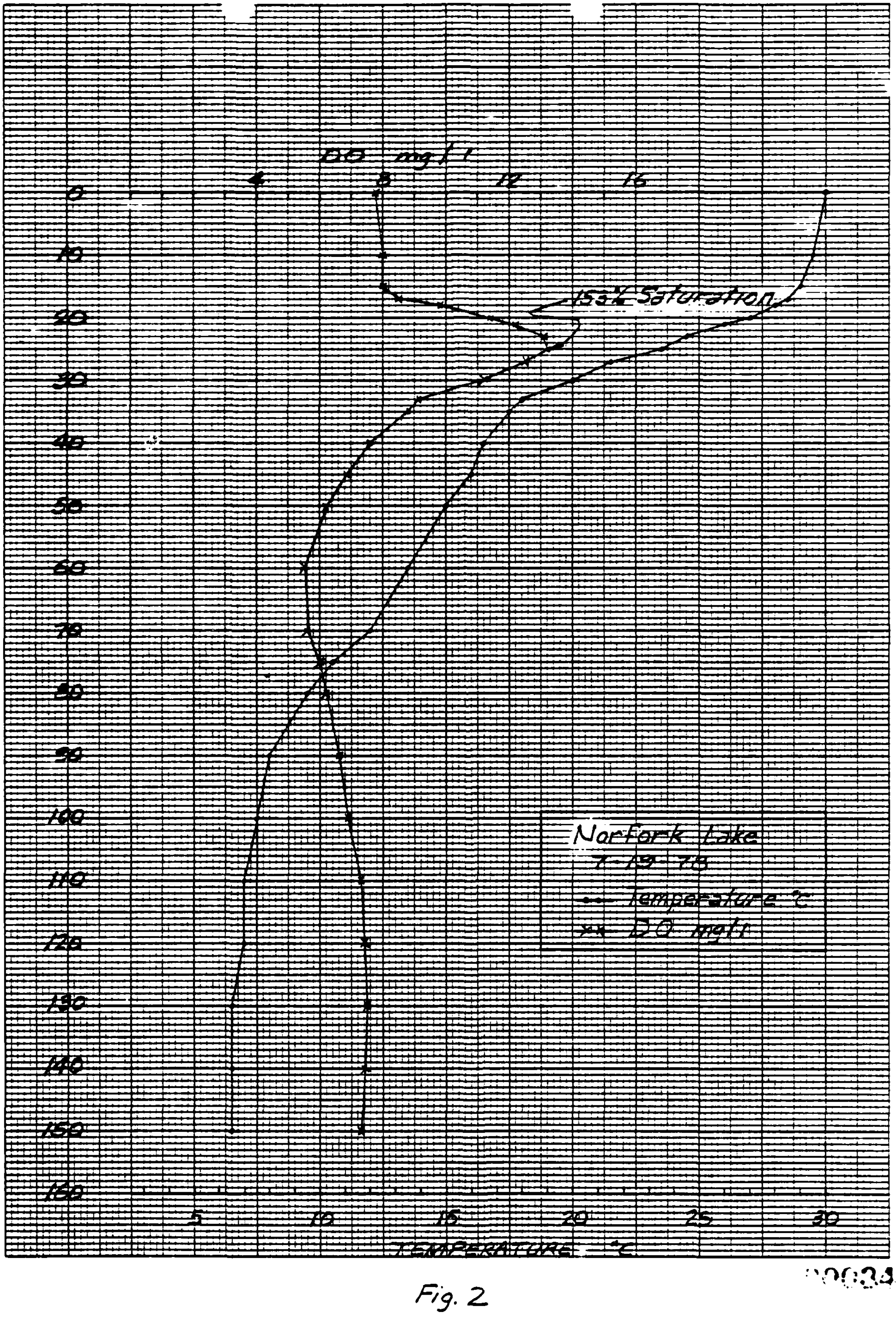
TEMPERATURE °C
Norfork Lake
5-23-78
Temperature °C
DO mg/l

Fig. 1.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153% Saturation
Norfork Lake
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Temperature °C
DO mg/l
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TEMPERATURE °C

Fig. 2

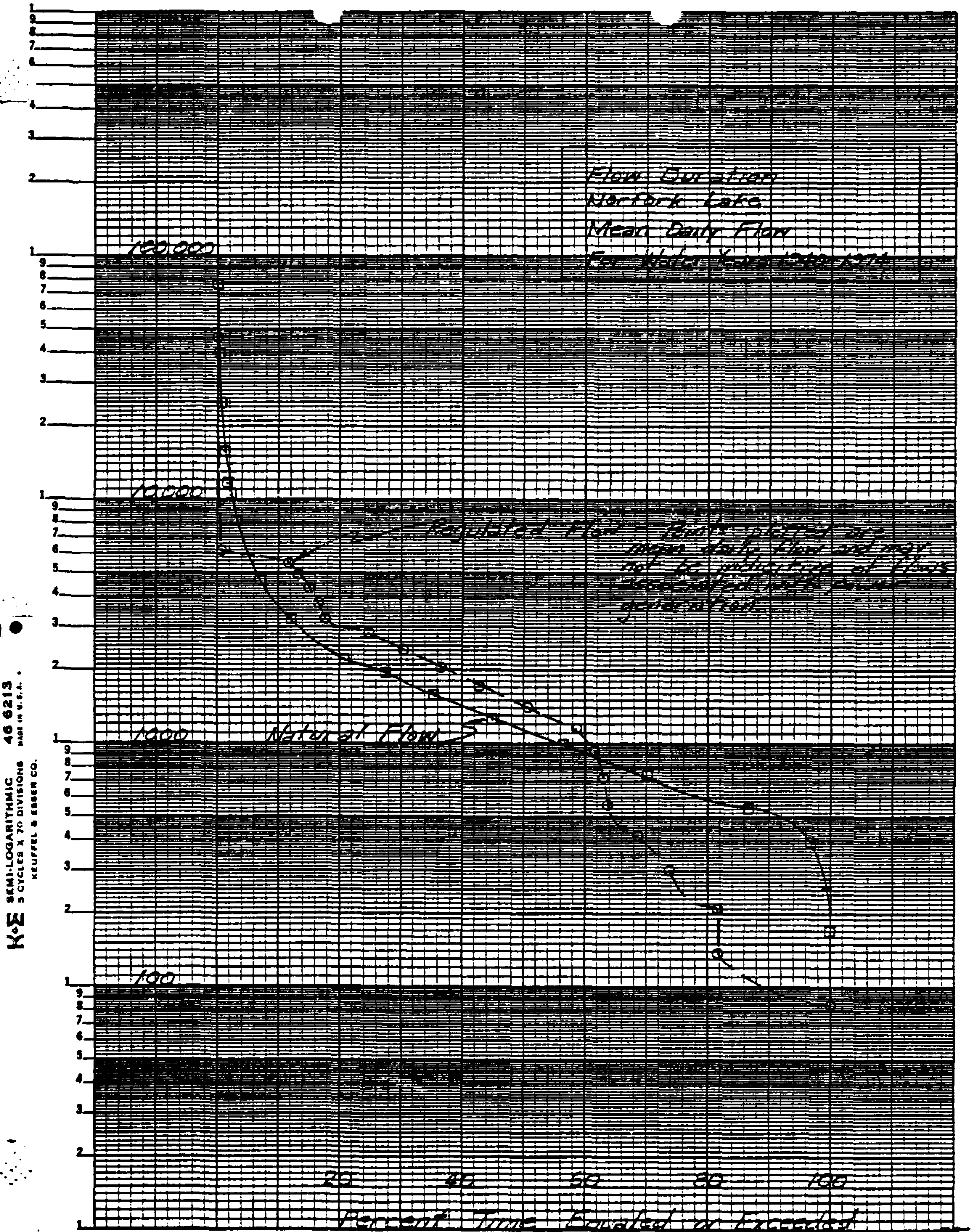

Flow Duration
Norfork Lake
Mean Daily Flow
For Water Years
100000
10000
1000
100
Regulated Flow - Points plotted are mean daily flow and may not be indicative of flows associated with power generation.
Natural Flow
20
40
60
80
100
Percent Time Equaled or Exceeded
K+E SEMI-LOGARITHMIC 46 6213
5 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.

Fig. 3

Clearwater Lake - Instream Flow Problems and Needs Evaluation

1. Project Name: Clearwater Lake.

2. Project Location: Clearwater Dam is located on the Black River at river mile 257.4, 5 miles southwest of Piedmont, Wayne County, Missouri. The lake lies almost entirely in Reynolds County. There are 898 square miles of drainage area above the dam. The principal downstream water management control stations are at Poplar Bluff, Missouri, on the Black River and at Newport, Arkansas, on the White River.

3. Type of Project:

a. General Category: Clearwater is one unit of a comprehensive plan for flood control and development of the water resources of the White River Basin and is operated for flood control and other purposes. A permanent conservation pool was provided which also offers excellent recreational opportunities.

b. Pertinent Data:

	Elevation ft. m.s.l.	Area Acres	Storage Capacity 1000 ac-ft	inches
Top of Dam	608.0			
Maximum Pool	602.5	17,200	897	18.7
Spillway Crest and Top of Flood Control	567.0	10,400	413	8.8
Top of Cons. (May-Oct)	498.0	1,870	28.8	0.6
Top of Cons. (Oct-May)	494.0	1,630	21.9	0.5
Flood Control Storage				
(May-Oct)	567-498	-	384.2	8.2
(Oct-May)	567-494	-	391.1	8.3
Streambed	454.0			

c. Outlets:

Type	No. & Size	Invert El. ft. m.s.l.	Opening Size & Control	Maximum Discharge (cfs) Top Cons.	Top Flood
Tunneled Conduit	1-23' dia.	467.0	3 - 9'x20' Tractor Gates	10,000	24,000

d. Hydropower Category: NA

4. Water Management Criteria:

a. Authorized Project Purposes: Flood control only.

b. Water Use Contracts: None

c. Interagency Agreements: None

d. Informal Commitments:

(1) In response to a variety of Federal, State, and local interests in Clearwater Lake, a low flow regulation plan was devised and modified in 1967 to manipulate the lake to enhance the propagation of fish, control mosquitos in the area, and improve the lake for fishing and boating in the fall. A minimum release of about 150 cfs was provided to insure that flows at Poplar Bluff, Missouri, remained at or above the historical minimum of about 180 cfs. This insures protection of existing water supply intakes at Piedmont and Poplar Bluff. Maintenance of fish life in the river, pollution abatement, and provides water for livestock and similar riparian

(2) The conservation pool is raised to elevation 498 on 1 May to increase general recreational use, fishery benefits, and storage to provide minimum releases all summer. At the beginning of the mosquito season on about 1 June a gradual drawdown of the pool is started and continued until elevation 496.5 is reached on about 15 September near the end of the recreation period. Then the lake level is lowered to elevation 494 on about 8 October. Thus, the pool is lowered away from encroaching vegetation. After 8 October the pool is held constant until 1 May except as required for regulation of floods.

(3) The drawdown was delayed approximately 1 month in 1979 and 1980 in response to a request by the Arkansas Game and Fish Commission (AG&FC). This permitted completion of construction work and snagging operations on the Black River Game Refuge in Arkansas. Also the delayed releases required to lower the pool were utilized by AG&FC to flood duck hunting areas in the refuge in late October and early November which is also nearer to the dormant season for hardwoods along the river.

(4) In response to local entreprenuers modified mosquito releases to provide larger flows on weekends and cut back to minimum on Monday -- Thursday.

e. System Regulation Objectives. Clearwater Lake is one of six existing reservoirs in the White River Basin with the capability to regulate floods. To accomplish this objective, the Black River stage at Poplar Bluff, Missouri, is used to regulate releases from Clearwater Lake, the White River stage at Newport, Arkansas, (downstream from the mouth of the Black) is used to regulate releases from Bull Shoals and Norfork Lakes, and the White River

stage at Georgetown, Arkansas, (downstream from the mouth of the Little Red River) is used to regulate releases from Greers Ferry Lake. The storage capability remaining upstream from Bull Shoals and Norfork is used in determining the prorata share of the total permissible daily release from this portion of the system. Usually, Clearwater releases are not regulated accordingly because they require over 11 days' travel time to Newport as compared to about 2 days for the Bull Shoals, Norfork releases. Only during major floods on the lower White River and Mississippi River or during special low flow operations is Clearwater included directly in the system operation.

5. Project Evaluation:

a. General: Table 1 summarizes pertinent water quality data obtained during the period 1974 through 1980 upstream near Highway K, within the lake (4 sites), and downstream of the dam. It contains mean values of up to 10 measurements taken at each location. Although the amount of data is insufficient to draw definite conclusions, it appears that nutrient concentrations do not change significantly in the lake or downstream, although the lake would be expected to act as a nutrient sink. Manganese concentrations exceed those of iron, which is the opposite of what would normally be expected. The lead concentration from upstream lead mines exceeds the Missouri standard (50 micrograms/liter for domestic water supply) at all locations within the system. The observed water quality conditions in and below Clearwater Lake reveal no deviations from Missouri WQ standards.

b. Effects of Impoundment on Water Stored:

(1) Positive Effects: Although there is limited water quality data on Clearwater Lake and the Black River, the lake should have some positive effects. The waters contain certain heavy metals (lead and zinc) from the extensive mining activities upstream of the lake and it should serve to reduce the amount of heavy metals moving in the river. Impoundment should cause fecal coliform bacteria to die off in the lake. The impoundment reduces the velocity of flood waters, thus preventing further scouring.

(2) Negative Effects: Clearwater Lake stratifies during late summer and early fall and the hypolimnetic waters become deficient in dissolved oxygen through natural processes. (DO readings range from 2.4 to 3.1 mg/l at depths of 18 to 20 feet). Concentrations of several constituents would be expected to be greater near the bottom. When stratification breaks up in late

TABLE 1

Clearwater Lake Project - WQ Data[1]

		Sample Location		
		Upstream[2]	In Lake[3]	Downstream[4]
Turbidity	JTU	2	7	9
DO	mg/l	10	9[5]	9.5
Iron	ug/l	20	30	120
Manganese	mg/l	100	200	300
Fecal Coliform	/100 ml	6	0	0
Nitrates + Nitrites	mg/l as N	0.12	0.1	0.09
Phosphorus	mg/l	0.04	0.02	0.03
Sulfates	mg/l	12	11	11
Lead	ug/l	100	100	100
Zinc	ug/l	90	80	60
pH	SU	7.4	7.3	7.2

[1]Mean values of up to 10 measurements at each station
[2]At Highway K bridge
[3]At four sites on the lake
[4]Near dam
[5]Average values of samples taken from an average depth of 4 feet

fall, increased concentrations of constituents such as dissolved iron and manganese are mixed throughout the impounded waters for a short period of time.

There is an increase in the turbidity of the waters in the lake which could be due to the shallow nature of the lake (rarely exceeding 40 feet deep at the dam site) or due to growth of algae in the lake. This turbidity is also noticed in the release waters.

Concentrations of lead and zinc are slightly higher than in other impoundments in the White River Basin.

Future water quality problems anticipated are associated with the increased recreational use of the streams and lake which may cause high bacterial counts.

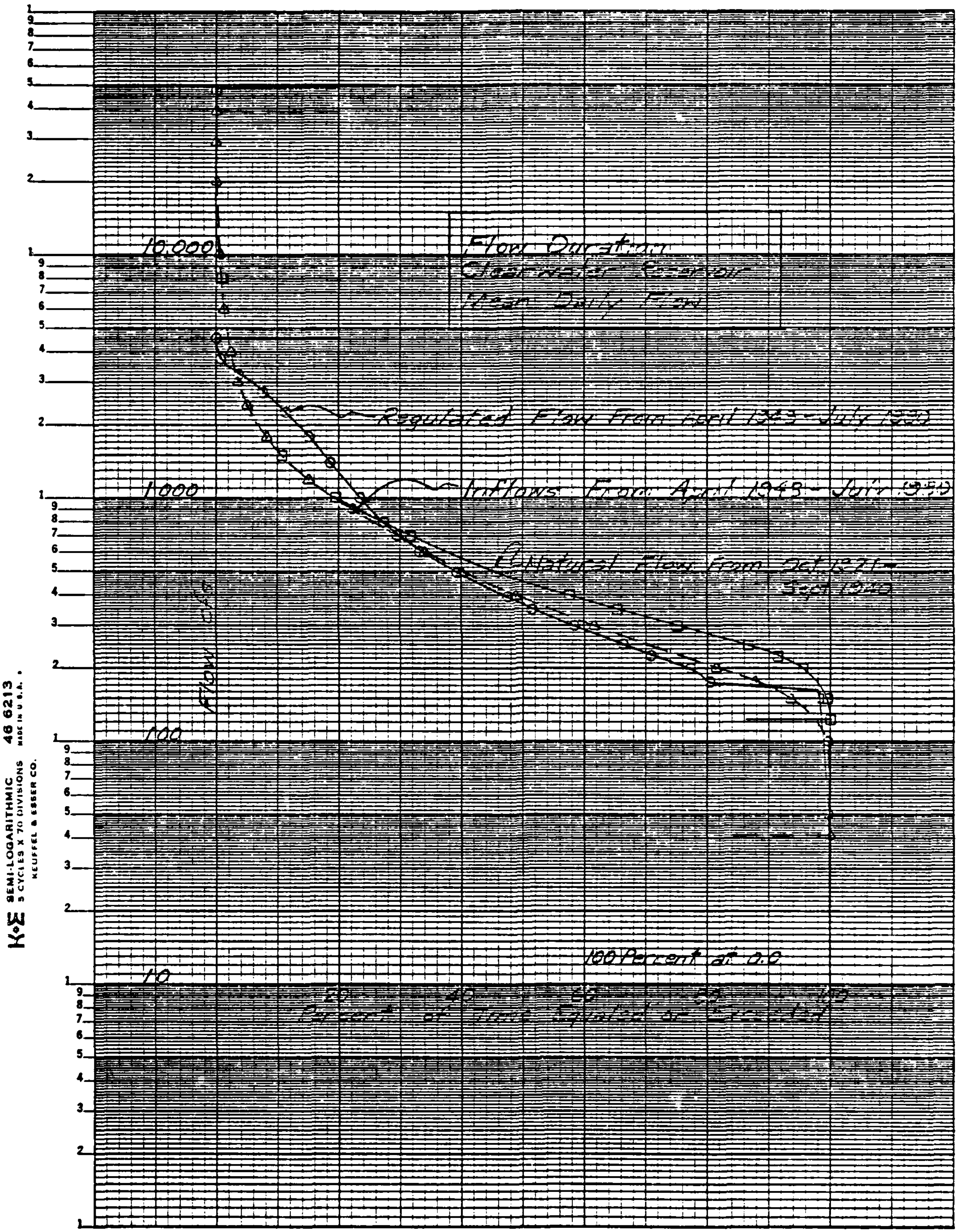
(3) Causes of Negative Effects: Clearwater Lake does not experience the large depletion of dissolved oxygen because of the shallow nature of the lake and because the inflow of cold oxygenated water flows under the epilimnion into the hypolimnion. Stratification is primarily a function of rising temperatues, and water quality deterioration in the lower depths follows stratification.

The lead and zinc concentrations are due to mining companies (Ozark Lead Co., Amax Lead Co., and St. Joe Mineral Co.), all of which have their own impoundments for their discharges. These industries are located near tributaries of the Black River. The effluent limitations set in the NPDES permits for these discharges should be stringent enough to prevent degradation.

The principle purpose of Clearwater Lake is flood control; however, the lake is used extensively for recreation. The projected population growth is minimal for the area, but based on facilities, size, and reported usage it is the most intensively used lake in the Little Rock District.

c. Project Effects on Instream Flows:

(1) General: Discharge-duration curves for the project inflows and releases as well as natural flows are shown on the inclosed exhibit. The releases from Clearwater Lake are regulated by a gage at Poplar Bluff, Missouri. Regulated releases rarely exceed 3,500 cfs, and the maximum release has been 4,540 cfs. With gage heights of less than 11.0 feet at Poplar Bluff and flows of 3,700 cfs, there is minor flooding of septic tanks of downstream development. Also deviations from the regulation plan have occurred due to claimed damages to hardwoods from the Arkansas State line to Corning, Arkansas.



Flow Duration
Clearwater Reservoir
Mean Daily Flow
Regulated Flow From April 1943 - July 1950
Inflows From April 1943 - July 1950
Natural Flow From Oct 1921 - Sept 1940
100 Percent at 0.0
Flow cfs
10,000
1000
100
10
20
40
60
80
100
Percent of Time Equaled or Exceeded
K&E SEMI-LOGARITHMIC 46 6213
5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO.

(2) Positive Effects: The flood control features of the project reduce the high flows and increase the duration of flows around bank full downstream of the dam. The low flow releases are normally significantly greater than preproject low flows, a 150 cfs minimum release was established to provide municipal and industrial water for Poplar Bluff and to replenish the pools downstream in the Black River for fishery purposes.

(3) Negative Effects: The data indicate that turbidity and concentrations of iron and manganese are higher downstream than the averages within the lake. Evacuation of stored floodwaters over an extended period may reportedly damage commercial and game management hardwood timber stands downstream. Conversely, delayed or extended evacuations will damage terrestrial vegetation around the lake and increase the chances of a damaging spill in the event of an unseasonal flood.

(4) Cause of Negative Effects: The increase in the concentration of certain constituents in the releases is related to the level in the lake from which the water is withdrawn and thus is due to the outlet configuration. Increased duration of flows that may damage timber stands is a result of flood control operations.

d. Project Effect on System Regulation: Clearwater Lake is included in the system regulation only during major floods on the Lower White River and Mississippi River or during special operations. Normally it is operated independently because the time of travel of flow from Clearwater Dam to Newport is much longer than from Bull Shoals and Norfork Dams to Newport.

6. Constraints on Obtaining Instream Quantity and Quality Objectives:

a. Quantity: There have been conflicts regarding the quantity of releases that have led to deviations from the approved regulating plan. For example, evacuation of floodwaters has been prolonged by lowering releases to allow drainage from timber stands and cropland that might be damaged by continued inundation. Levying of low-lying agricultural lands is becoming more of a problem affecting flood heights.

b. Quality: None.

7. Alternatives:

a. Reservoir Regulation: The present regulation plan, although generally adequate for downstream quantity needs, should be reevaluated.

b. Structural Modification: NA

c. Storage Reallocation: NA

d. Other: NA

8. Actions Taken To Date: None

9. <u>Planned Actions</u>: A study is planned to determine the feasibility of changing the regulation plan to reduce flood damages. A water quality study is proposed to determine the heavy metal characteristics of the lake and its releases. This study would cost approximately $10,000 and would take 9-12 months to complete. Unless supplemental funds were available, this study could not be budgeted for earlier than FY 83.

GREERS FERRY LAKE - INSTREAM FLOW PROBLEMS
AND NEEDS EVALUATION

1. Project Name: Greers Ferry Lake.

2. Project Location: Greers Ferry Dam is located on the Little Red River at river mile 79.0, 3 miles northeast of Heber Springs, Cleburne County, Arkansas. There are 1,146 square miles of drainage area above the dam. Downstream water management control stations are located at Judsonia on the Little Red River and Georgetown on the White River.

3. Type of Project:

a. General Category: Of the six lakes constructed in the White River Basin, Greers Ferry is one of five which are multipurpose for flood control, generation of hydroelectric power, and other beneficial purposes. The project also offers excellent recreational opportunities.

b. Pertinent Data:

	Elevation ft m.s.l.	Area Acres	Storage Capacity 1,000 Ac ft	Storage Capacity Inches
Top of Flood Pool	487.0	40,480	2,844.5	46.5
Spillway Crest	453.0			
Top of Conservation Pool	461.0	31,460	1,910.5	31.2
Nominal Bottom of Power Drawdown Storage	435.0	23,740	1,194	19.5
Flood Control Capacity	487 - 461(1)	-	934	15.3
Power Storage	461 - 435(1)	-	716.5	11.7
Stream Bed	260.0			

(1)The top of the seasonal power pool will be elevation 462.0 on 1 May and elevation 461.5 from 1 June to 1 October.

c. Outlets:

Type	No. & Size	Invert El. ft msl	Opening Size & Control	Maximum Discharge (cfs)(3) Top flood	Top conservation
Ogee Spillway	1 - 240' (Net total)	453.0	6 - 40'x 36' Tainter gates	174,000	- - -
Sluice	1 - 5'8"x 10'	283.0	2 - hydraulic Slide gates	5,300	4,990
House Unit	1 - 42"	329.25	30" valve		20
Hatchery	1 - 24"	331/370.5/ 409.7(1)			7,500 gpm(2)
Power Units	2 - 18.5' dia	331.2	2-23'2"x 16'7" Hoist gates	6,300	6,900

(1) Multilevel intake.
(2) Pumping rate used by the hatchery.
(3) Turbine discharges at rated capacity.

d. Power Development:

Power Units:	
Main generating units, number	2
Rated capacity, each unit, kW	2 @ 48,000
Total capacity, kW	96,000

4. Water Management Operating Criteria.

a. Authorized Project Purposes. Greers Ferry is one of five multiple purpose projects constructed in the White River Basin for the control of floods and the generation of hydroelectric power. The project also offers excellent recreational and fish and wildlife opportunities. Storage for water supply is included.

b. Water-use Contracts.

(1) Operational.

(a) City of Clinton, Arkansas, 900 acre feet. 1970.

(b) Community Water System. 225 acre feet. 1971.

(c) Community Water System. 675 acre feet. 1980.

(d) Fairfield Bay. 75 acre feet. 1980.

(e) First Pyramid Life Insurance Company of America. 237 acre feet. 1980.

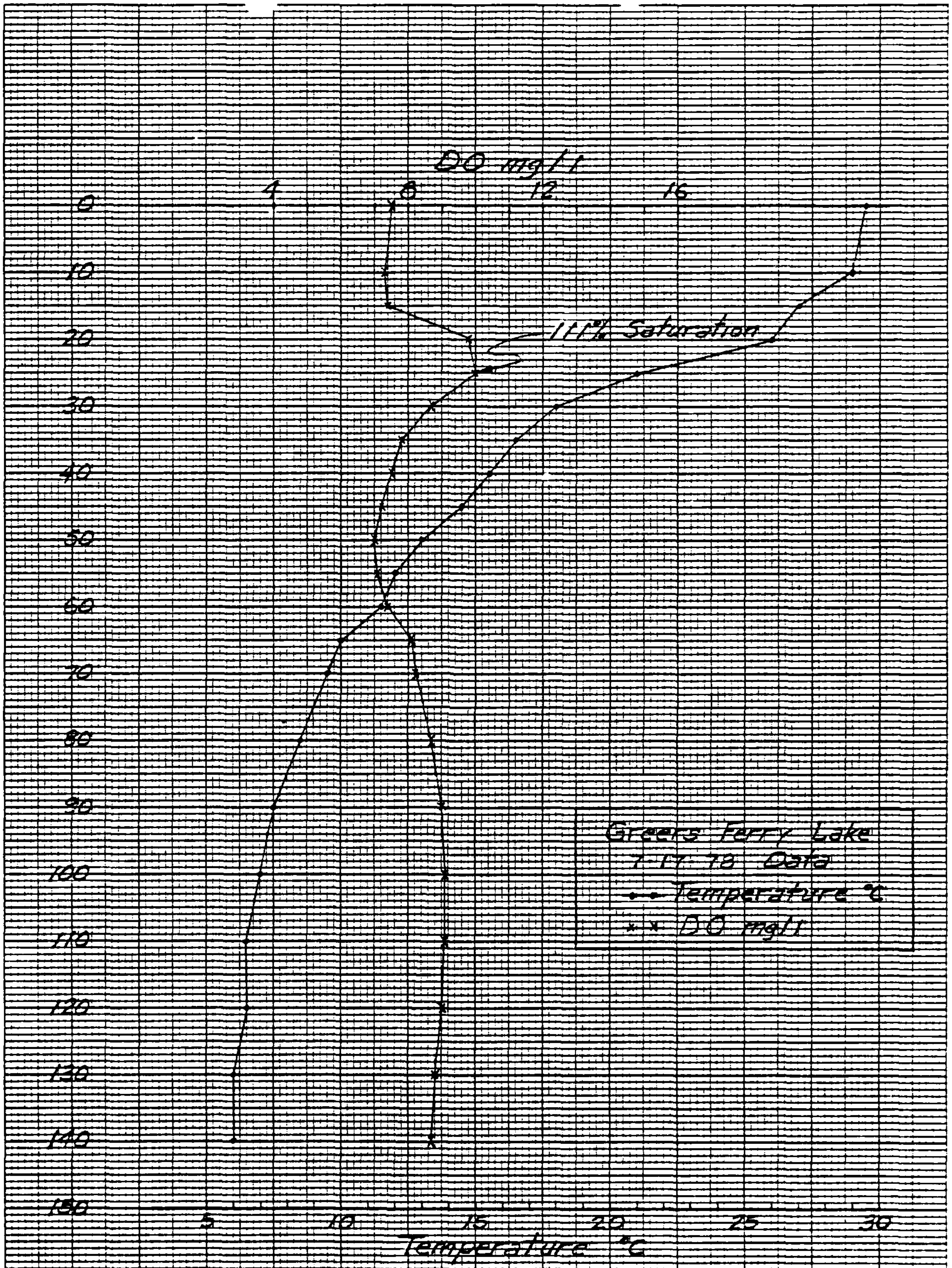


Fig. 1

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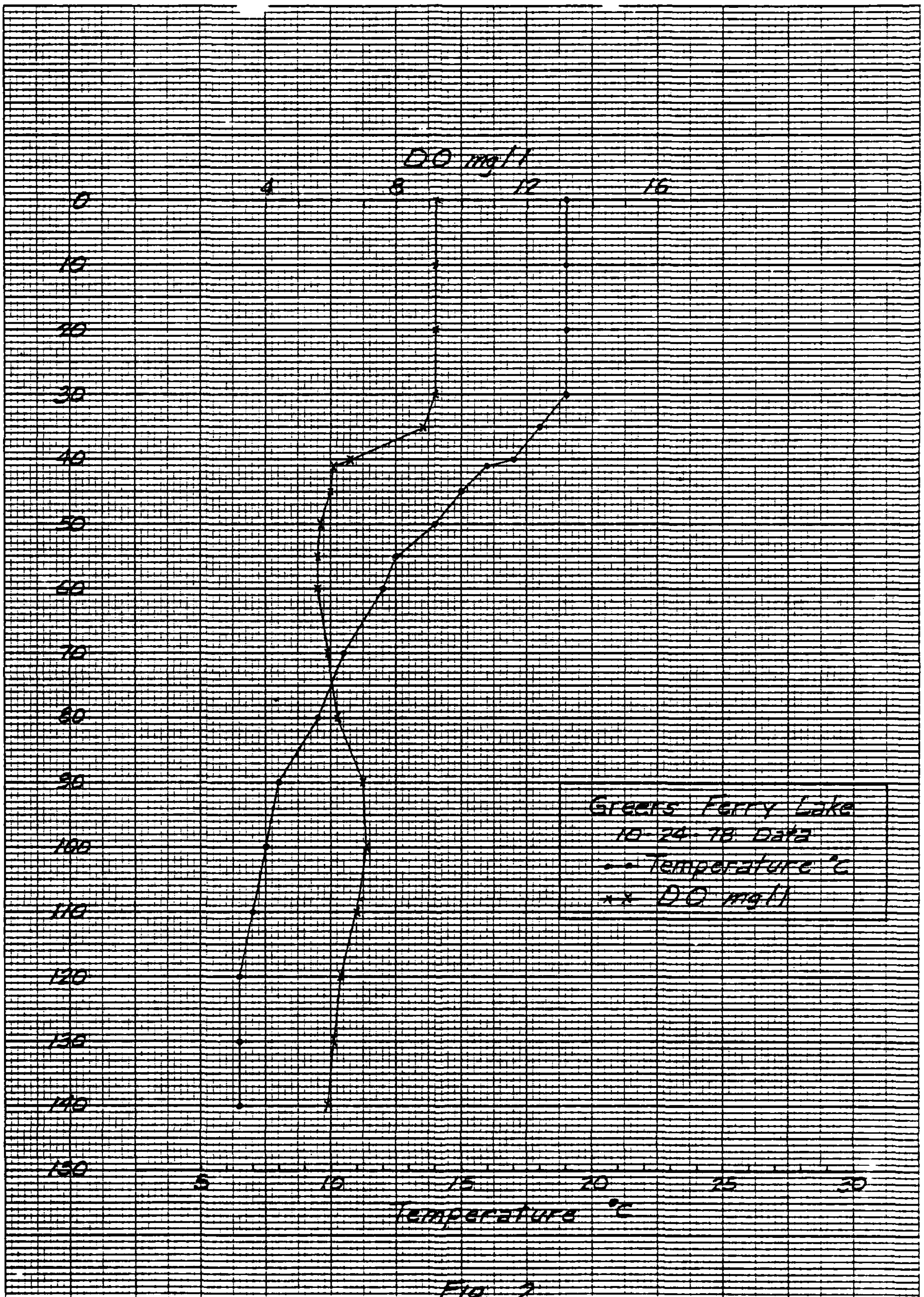
DO mg/l
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15
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30
Temperature °C
Greers Ferry Lake
10-24-78 Data
Temperature °C
DO mg/l

Fig. 2

00047

c. Interagency Agreements: None.

d. Informal Commitments: The Corps, Southwestern Power Administration, and the Arkansas Game and Fish Commission (AG&FC) have agreed that minimal daily power releases will be made for the trout fishery and flow maintenance between 1 May and 30 September and at other times as needed based on air temperature forecasts by the National Weather Service. These releases range from 115 to 225 cfs. Special releases are scheduled as needed to flush out muddy water downstream due to runoff below the dam or stagnant water during extended periods of no generation. Storage for the releases is provided by a seasonal buffer zone between the flood control and power pools which also enhances power and recreational usage.

Lake level manipulations to enhance fish spawns were conducted at Greers Ferry Lake in 1976 and 1979. Smaller scale special operations have been conducted for events such as trout fishing tournaments, canoe races, clean ups, and stocking fish. These have involved no releases, controlled releases, or specially timed releases depending on the conditions required.

e. System Regulation Objectives: Greers Ferry Lake is the farthest downstream reservoir in the White River system and, insofar as the White River is concerned, is operated as a holding reservoir for flow conditions as modified by upstream reservoirs. When flow on the Little Red River results in storage of flood flows in Greers Ferry, releases are controlled by the uncontrolled flow on the Little Red River downstream from Greers Ferry, releases for generation of firm power, or stages on the White River at Georgetown, Arkansas. The minimum release from the project during such periods is 3,000 cfs except for periods when the uncontrolled flow exceeds the maximum channel capacity of 15,000 cfs on the Little Red River.

5. Project Evaluation:

a. General: Greers Ferry probably has the best water quality of five White River lakes which have basically similar water quality characteristics. These large deep lakes begin to stratify in late spring or early summer and remain stratified until late fall or early winter. Stratification in the lakes is very strong, with temperature differentials between the surface and bottom frequently exceeding 20°C in July. Figures 1 and 2 are typical summer and fall stratification patterns in Greers Ferry Lake. The metalimnion does not exhibit the extremely high or low levels of dissolved oxygen that other White River lakes have.

The AG&FC and the U.S. Fish and Wildlife Service have established a cold water fishery in the Little Red River from Greers Ferry Dam approximately 26 miles downstream and within the hypolimnion of the lake itself. Both are artificially maintained by stocking trout reared at the Greers Ferry National Fish Hatchery located directly below the dam. The Arkansas water quality standard for temperature in a trout stream is 68°F. The releases from Greers Ferry generally range from 39 to 55°F. Warming occurs downstream, however, and releases as described in paragraph 4d are necessary to minimize adverse effects on the trout.

Greers Ferry Lake experienced a problem associated with the operation of the Greers Ferry National Fish Hatchery in the mid to late 1960's. Correlation was obtained between rainbow trout (*Salmo gairdneri*) mortality and manganese concentration in the hatchery water during the period from 8 November through 1 December 1967. The hatchery used water from the hypolimnion from an intake port located at elevation 331 ft. From a study by J. Nix, Department of Chemistry, Ouachita Baptist University, it was proposed that the water from the hypolimnion being used by the hatchery contained toxic conditions for the trout. However, additional work is needed to test this hypothesis. A multiple intake port was constructed for the hatchery in 1978 in order to draw water from nearer the surface. Now, water is drawn from elevation 409.7 ft from April through July and from elevation 370.5 ft from July through April. Since the installation of these intakes, there have been no adverse affects noticed by the hatchery.

Table 1 summarizes certain water quality data obtained during the period 1974 to 1979 from tributaries entering the lake, within the lake (3 stations) and downstream near the dam. It contains mean values of up to 50 measurements at each station.

The water quality of Greers Ferry Lake is similar to the other White River Basin projects with the exception of specific conductivity. This particular parameter is consistently lower than in other lakes in the District primarily due to the geological features of the lake bed and drainage area.

On the basis of nutrient concentrations and other data and field observations, Greers Ferry Lake was classified as mesotrophic by EPA's National Eutrophication Survey. Phosphorus appears to be the limiting nutrient. Almost 90 percent of the phosphorus load to the lake comes from nonpoint sources.

Table 1
Greers Ferry Lake Project - WQ Data[1]

Parameter	Sample Location: Upstream[2]	Lake[3]	Downstream[4]
Temperature(°C)	18	—[5]	10
Specific Conductance(@25°C micro Mho)	38	38	42
Turbidity (JTU)	15	6	5
pH (SU)	6.8	6.6	6.7
Dissolved Oxygen (mg/l)	8.0	—[5]	9.5
Nitrates & Nitrites (mg/l N)	0.06	0.2	0.2
Phosphorous (mg/l)	.05	.05	.05
Alkalinity (mg/l)	11.4	15	14
Fecal Coliform (#/100ml)	13	8	3
Iron (ug/l)	650	380	220
Manganese (ug/l)	170	150	80

[1] Mean values of up to 50 measurements at each station (1974 - 1979).
[2] At 4 stations on tributaries entering lake.
[3] At 3 stations on the lake.
[4] Near Heber Springs below dam.
[5] Omitted because of the wide range with both depth and season.

b. Effects of Impoundment on Water Stored:

(1) Positive effects: The Little Red River has low levels of solids, turbidity, and color; and these parameters are reduced even more by impoundment. Particulate forms of iron and manganese settle out in the lake. Coliform bacteria entering the lake from both runoff and point sources die off in the lake.

(2) Negative effects: During the latter stages of stratification, the oxygen in the lower depths in the hypolimnion is depleted to extremely low values with the formation of a reducing environment. Under this environment, objectionable compounds such as hydrogen sulfide may develop, and the leaching rate of constituents such as iron and manganese will be increased. When stratification breaks up in early winter, increased concentrations of these dissolved constituents are mixed throughout the lake depths for short periods of time.

There are negative effects that are due not to the process of impoundment but rather to the existence of the impoundment. These include excessive nutrients, bacteria, and biochemical oxygen demand contributed by both point and nonpoint sources around the lake. Problems from these pollution loads are usually confined to arms of the lake where the pollutants enter, sometimes resulting in oxygen depletion and subsequent fishkills and odors.

(3) Causes of negative effects: Stratification is the result of seasonal warming of the epilimnion. Extensive development around the lake is the cause of excessive levels of some pollutants. Lack of proper disinfection at the city of Clinton sewage treatment plant has resulted in consistently high bacteria counts in the South Fork arm of the lake. Over 200 subdivisions located adjacent to the lake have homes with individual septic tanks. As development continues, associated problems will intensify; and unless appropriate plans are developed, the overall quality of the lake will be significantly degraded.

c. Project Effects on Instream Flows:

(1) General: Figure 3 shows both the regulated (existing) and natural annual flow duration curves for flows at the dam. Monthly flow durations for existing and natural conditions are shown in Figures 4 through 15 and 16 through 27, respectively. These figures represent a computer model simulation of mean daily flows for a period of record from October 1939 through September 1974.

(2) Positive effects: The coldwater releases have allowed the development of a very popular trout fishery. The flood control feature of the project reduces the high flows and increases the duration of subsequent floodwater evacuation near bank full flows downstream of the dam and on the White River. Normal power releases increase the duration of low flows downstream from the dam. The minimal low flow releases, combined with station service unit and hatchery releases and leakage, are normally significantly greater than preproject low flows, which were occasionally zero.

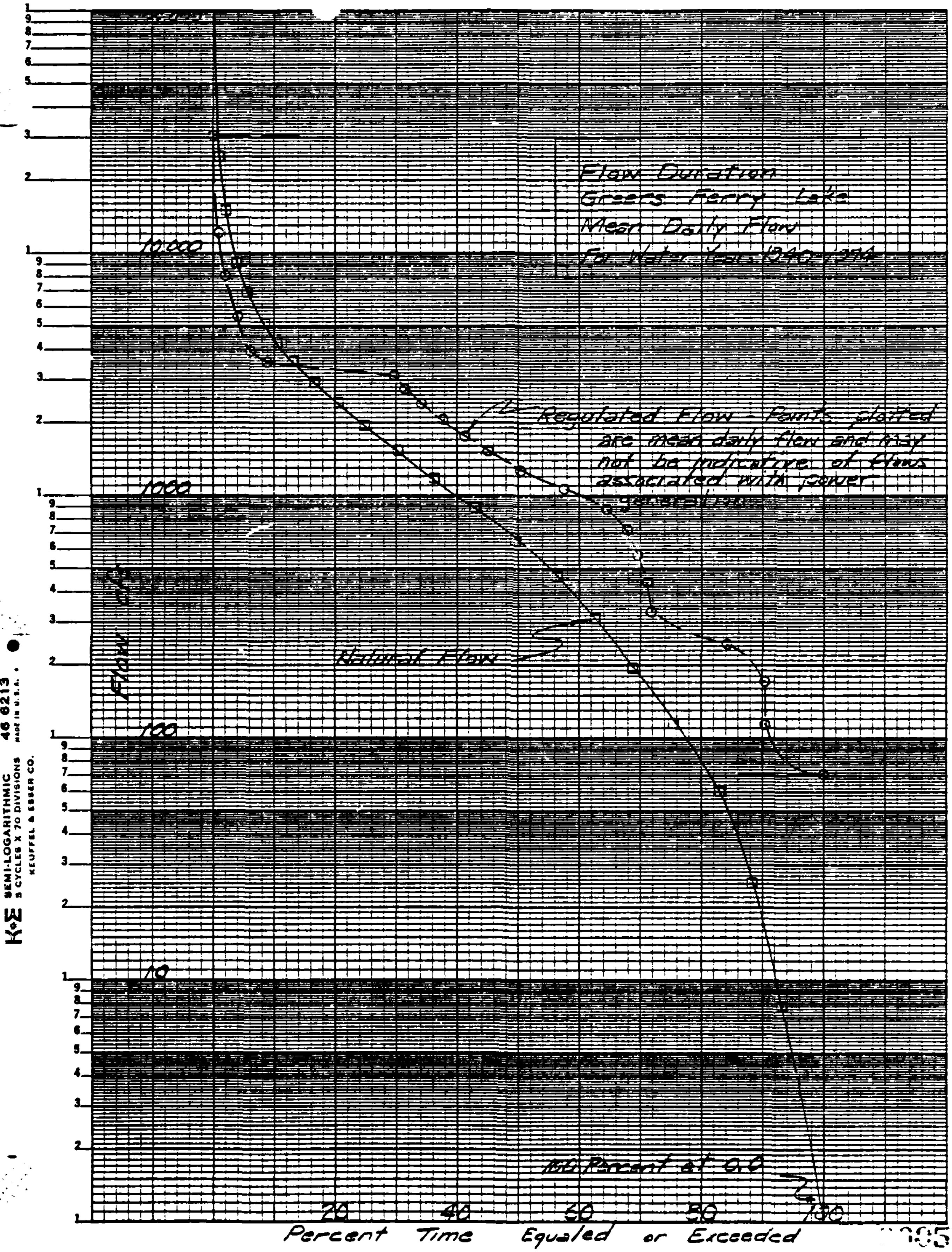

Flow Duration
Greers Ferry Lake
Mean Daily Flow
For Water Years 1940-1974
Regulated Flow - Points plotted are mean daily flow and may not be indicative of flows associated with power generation
Natural Flow
100 Percent at 0.0
Flow cfs
10,000
1000
100
10
20
40
60
80
100
Percent Time Equaled or Exceeded
SEMI-LOGARITHMIC 46 6213
5 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.

Fig. 3

00052

(3) Negative effects: Occasionally releases are deficient in dissolved oxygen, but they quickly reaerate downstream as the water flows over existing shoals. Creation of the artificial cold water fishery resulted in a "transition zone" between the cold water fishery and the original warm water fishery further downstream. Water within this 20 mile zone is too warm for trout and too cold for warm water species. The upper and lower limits of the transition zone are approximately the Ramsey Public Access Area and the Searcy water supply intake, respectively. Problems have occurred in the past during hot weather periods when there were not adequate power releases to maintain proper water temperatures downstream.

(4) Causes of negative effects: The occasional release of oxygen deficient water is due to lake stratification and the level in the lake from which the water is withdrawn. The warming of the water downstream is a natural process compounded at times by warm water inflow from downstream tributaries.

d. Project effects on system regulation: The minimum discharge of 3,000 cfs when water is stored in the flood control pool is sufficient to keep the flood control pool from filling except in exceptional flood conditions, yet this discharge will increase stages on the lower White River during the emptying period less than 0.5 foot over those which would result from minimum firm power releases from Greers Ferry. There is no significant advantage to completely curtailing releases on the crest of White River rises as crests are primarily a function of the volume of flow on the river rather than closely related to distribution of flow. Thus the Greers Ferry Lake project has a significant effect on system regulation only in the holdouts of flood flows.

6. Constraints on Obtaining Instream Quantity and Quality Objectives:

a. Quantity: Hydroelectric power generation is the primary constraint on satisfying the downstream water uses. Power releases vary significantly depending on generation rates. Some fishery interests contend that larger continuous releases should be made only at night. Others prefer only minimal or occasional releases to enhance bank fishing and wading. Serious consideration has been given to using Greers Ferry releases as a source of water for the mid-Arkansas Regional Water Distribution District, but the va iability of the releases limits the feasibility of this option.

Developments such as Rainbow Island which are built in low areas could be a temporary constraint on the operation of the project for flood control. However, once the flood pool is filled, the resulting flood releases may require evacuation of the development area. Extended periods of relatively large flood control releases are frequently constraints to trout fishing and other recreational usage of the downstream channel in the spring and early summer.

b. Quality: The need to release water daily during hot weather to avoid fish kills often conflicts with the optimum pattern of power generation.

7. Alternatives:

a. Reservoir Regulation: The present regulation plan is generally considered adequate for downstream quantity needs, but alternative plans are

being investigated as part of the White River Lakes Study. Water quality problems associated with the current regulation plan will be addressed in that study and alternative plans will be developed and evaluated.

b. Structural Modification: Structural modifications are not considered applicable since problems can be ameliorated through operational modifications.

c. Storage Reallocation: Reallocation of storage is being addressed in the White River Lake Study as described in paragraph 8.

d. Other: NA

8. Actions taken to date: The wastewater management studies for the Greers Ferry Lake Environmental Protection Study are being performed by A-E contract. The first contract is to determine wastewater and solid waste problems and needs in the study area and will present various general solutions that could potentially alleviate the problems. Various alternative operating plans, including storage reallocation, are being addressed in the White River Lakes Study. In addition, in-stream flow needs are being addressed and each alternative operating plan will be evaluated. This phase of the study is being coordinated closely with various fish and wildlife agencies.

9. Planned Actions: Future contracts will develop alternative plans to satisfy the problems and needs, and eventually one or two plans will be finalized. Institutional analysis studies will be contracted in order to develop institutional arrangements or entities for implementation of the selected plans. As part of this water quality management study, a modeling study is proposed to determine the optimum release scheme that will minimize adverse temperature conditions downstream. This study would take approximately 6 months and cost $20,000. It would involve collection of water quality data and discharge measurements during hot weather periods and calibration of a water quality model such as the water quality for River-Reservoir Systems model. The model would then be used to evaluate various release schemes.

1. Project Name: TRINIDAD LAKE

2. Project Location: Trinidad dam is located at river mile 160.5 on the Purgatoire river which is a tributary to the Arkansas river. The watershed above Trinidad dam is 671 square miles and all in the State of Colorado. The primary control is at Trinidad, Colorado.

3. Type of Project:

a. General category: multi-purpose.

b. Storage allocations:

	Elevation (Feet NGVD	Storage (Acre-feet)	Storage (Inches-runoff)
Flood Control	6230-6258	53,900	1.51
Water Supply	6210-6230	20,000	0.56
Sediment Space		39,000	1.09
Recreation		4,500	0.13

c. Hydropower category: none.

4. Water Management Criteria:

a. Authorized project purposes: Flood control, sediment retention, water supply and recreation.

b. Water use contracts: WPRS irrigation.

c. Interagency agreements: WPRS.

d. Informal commitments:

e. Systems regulation objectives: Operated in compliance with the Arkansas River Compact and Colorado State Law.

5. Project Evaluation:

a. Effects of impoundment on water stored:

(1) Positive effects: Reduces turbidity and sediment movement.

(2) Negative effects: There is a possibility that water pH might be lowered.

(3) Cause of negative effects: Storage area contains many old coal mines and tailings area. Water stored over such area can be affected by leaching action.

b. Project effects on instream flows:

(1) General: Reduces peak flows and increases duration of flow. All flow is appropriated under Colorado State Law and apportioned under the interstate compact between Colorado and Kansas.

(2) Positive effects:

(3) Negative effects:

(4) Cause of negative effects:

c. Project effects on system regulation: Project operated primarily to provide flood protection for City of Trinidad.

6. Constraints on Obtaining Instream Quantity and Quality Objectives.

a. Quantity: All flow appropriated under state law.

b. Quality:

7. Alternatives.

a. Reservoir regulation. None.

b. Structural modification. None.

c. Storage reallocation. Not applicable.

8. Actions Taken to Date:

9. Planned Actions:

1. Project Name: JOHN MARTIN RESERVOIR

2. Project Location: John Martin dam is located at mile 1,158.7 on the Arkansas river which is a tributary to the Mississippi river. The Arkansas watershed above John Martin is 18,130 square miles and located in the state of Colorado. Water management stations are: Lamar, Colorado; Garden City, Dodge City and Great Bend, Kansas.

3. Type of Project:

a. General category: multi-purpose

b. Storage allocations:

	Elevation (Feet NGVD	Storage (Acre-feet)	Storage (Inches-runoff)
Flood Control	3851-3870	270,000	0.28
Water Supply	3766-3851	350,000*	0.36
Recreation (In water supply pool)	--	10,000	--

A recreation pool was established in 1979 with transmountain water.

c. Hydropower category: No power.

4. Water Management Criteria:

a. Authorized project purposes: Flood control and water supply.

b. Water use contracts:

c. Interagency agreements: none.

d. Informal commitments: none.

e. Systems regulation objectives: Operated in compliance with the Arkansas river compact. Project flood control operation is to minimize flood damage.

5. Project Evaluation:

a. Effects of impoundment on water stored:

(1) Positive effects: First year of impoundment of a permanent pool. Effects are unknown.

(2) Negative effects:

(3) Cause of negative effects:

b. <u>Project effects on instream flows</u>:

(1) General: Reduces peak flow and increases duration of flow. Reduces turbidity and sediment movement. Total stream flow appropriated and apportioned under Colorado State law and the interstate compact between Colorado and Kansas.

(2) Positive effects:

(3) Negative effects:

(4) Cause of negative effects:

c. <u>Project effects on system regulation</u>:

6. <u>Constraints on Obtaining Instream Quantity and Quality Objectives</u>.

a. <u>Quantity</u>: All flow appropriated under state law.

b. <u>Quality</u>:

7. <u>Alternatives</u>.

a. <u>Reservoir regulation</u>. None.

b. <u>Structural modification</u>. None.

c. <u>Storage reallocation</u>. Not applicable.

8. <u>Actions Taken to Date</u>:

9. <u>Planned Actions</u>:

1. Project Name: El Dorado Lake

2. Project Location: River Mile 100.2 on Walnut River tributary to Whitewater River. Project watershed (234 square miles) located in Kansas; downstream management control stations located in Kansas.

3. Type of Project:

a. General Category: Multiple-purpose storage reservoir (excluding hydropower).

b. Storage Allocations:

	Elevation Feet (N.G.V.D.)	Storage Acre-Feet	Storage Inches Runoff
Top Flood Control Pool	1347.5	236,200	18.93
Top Conservation Pool	1339.0	157,000	12.58
Bottom Conservation Pool	1296.0	2,900	.23
Water Supply Storage (22.2 mgd)		142,800	
Water Quality (interim use)			

4. Water Management Criteria:

a. Authorized Project Purpose: Flood control, water supply, water quality, and recreation.

b. Water Use Contracts: Water storage - 22.2 mgd

c. Interagency Agreements: The State of Kansas contracts for all the water supply storage available.

d. Informal Commitments: None

e. System Regulation Objectives: The project is regulated in the system to control floods and retain equivalent flood control capabilities with other projects in the system.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(b) Quantity: The lake provides storage for flow augmentation until all water storage has been contracted.

(2) Negative effects:

(a) Quality: Due to the basin morphometry, El Dorado Lake stratifies only occasionally. Such weak and ephemeral stratification is not associated with water quality degradation.

b. Project Effect on Instream Flows:

(1) General: Natural frequency and duration curves are attached. The predicted modified duration curve is also included.

(2) Positive effects: The modified peak discharge magnitudes will be decreased as water supply contracts increase.

(3) Negative effects: Low flow durations are reduced. No water quality problems are expected.

c. Project Effects on System Regulation: The project will significantly improve the flood controlling capabilities on the Verdigris River.

6. Alternatives:

a. Reservoir Regulation: None

b. Structural Modification: None

c. Storage Reallocation: None

d. Other: No action

7. Action Taken To Date: None

8. Planned Action: None

EL DORADO
WALNUT RIVER, KANSAS

Top of Conservation (Power) Pool Elevation	1339.0
Top of Flood Control Pool Elevation	1347.5

OUTLET WORKS

Type	Conduit
Size	11.5'x15.75'
Intake Elevation	1279.0
Control Gates	2-5.5'x15.75'
Capacity at Conservation Pool (c.f.s.)	6600
Capacity at Flood Control Pool (c.f.s.)	7100

WATER SUPPLY FACILITY

Intakes			
Number	2	2	2
Size	3'x4'	3'x4'	3'x4'
Elevation	1327.0	1309.0	1290.5

Low Flow	
Type	Sluice
Size	2.0'x3.0'
Elevation	1302.0
Capacity at Conservation Pool (c.f.s.)	247
Capacity at Flood Control Pool (c.f.s.)	263

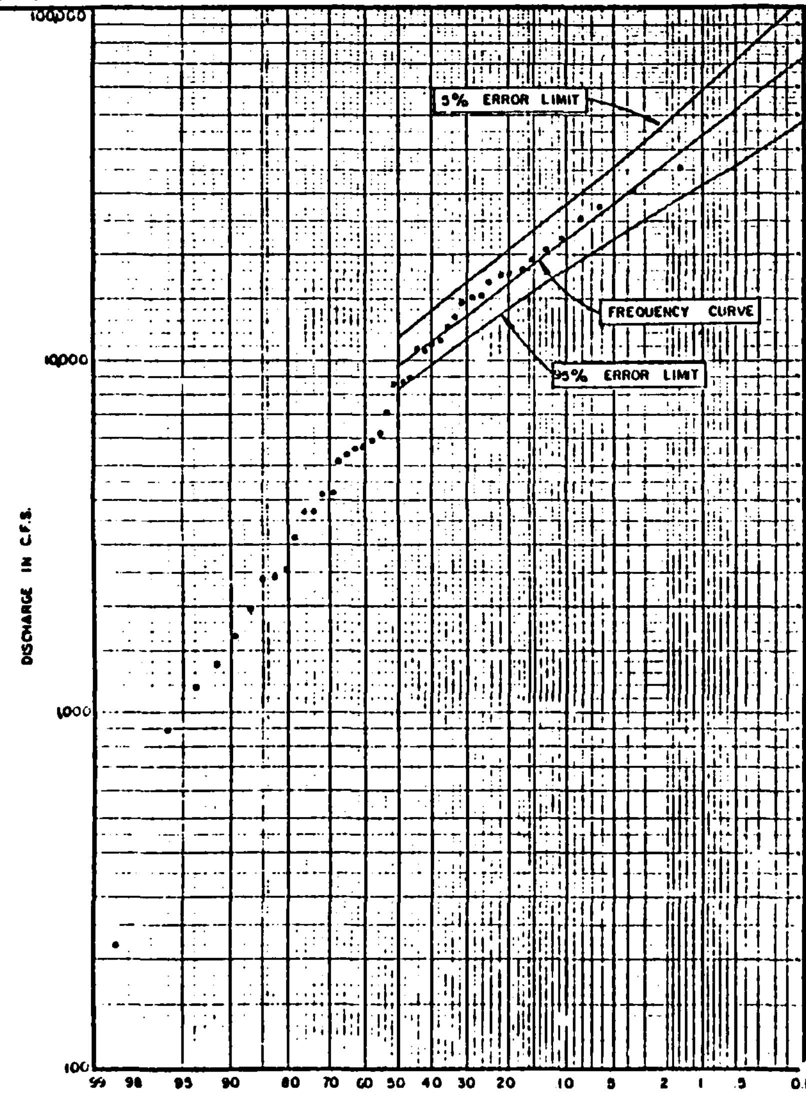
Static Head Pipe	
Diameter	36" Dia.
Elevation	1274.0

SPILLWAY

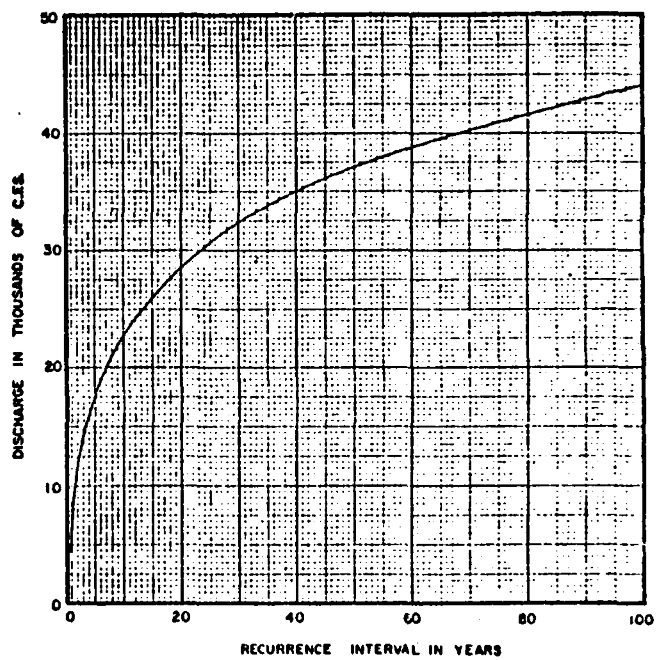
Type	Excavated
Crest Width	350'
Crest Elevation	1353.0
Control	Uncontrolled
Capacity at Conservation Pool (c.f.s.)	0
Capacity at Flood Control Pool (c.f.s.)	0

CORPS OF ENGINEERS

U. S. ARMY



CUMULATIVE FREQUENCY CURVE OF ANNUAL PEAK FLOWS



DISCHARGE PROBABILITY UNDER NATURAL CONDITIONS

NOTES:
1. BASED ON METHODS OUTLINED IN "STATISTICAL METHODS IN HYDROLOGY" LEO R. BEARD, JAN. 1962.
2. BASIC DATA ARE COMPUTED ANNUAL PEAK DISCHARGES AT THE DAM SITE FROM OCT. 1921 THROUGH SEPT. 1965.

EL DORADO RESERVOIR
WALNUT RIVER, KANSAS

PEAK DISCHARGE FREQUENCY CURVES AT EL DORADO DAM SITE R. M. 98.0

U. S. ARMY ENGINEER DIST., TULSA, CORPS OF ENGINEERS JUNE 67
DRAWN: D.A.P.
CHECKED: G.G.B.

DMI-99/10

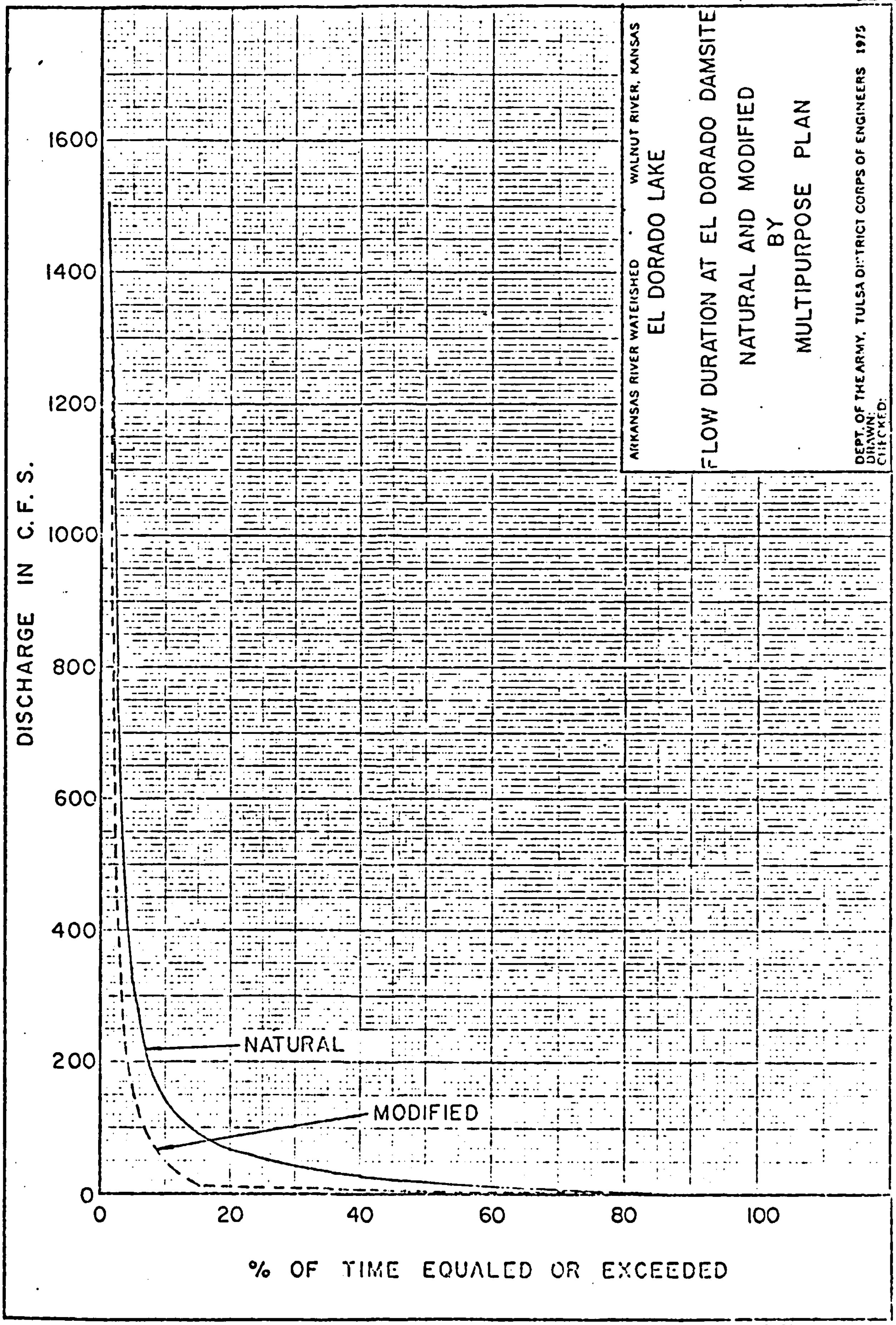


EXHIBIT NO. 22

1. Project Name: Kaw Lake

2. Project Location: River mile 653.7 on Arkansas River tributary. Project watershed (46,530 square miles) located in Oklahoma; downstream management control stations located in Oklahoma and Arkansas.

3. Type of Project:

a. General category: Multipl~-purpose storage reservoir (excluding hydropower).

b. Storage allocations:

	Elevation (feet) (N.G.V.D.)	Storage Acre feet	Storage Inches Runoff
Top Flood Control Pool	1044.5	1,348,000	3.80
Top Conservation Pool	1010.0	428,600	1.21
Bottom Conservation Pool	978.0	85,100	.24
Water Supply Storage (167 mgd)		171,200	
Water Quality Storage (34 mgd)		31,800	

4. Water Management Criteria:

a. Authorized project purposes: flood control, water supply, water quality, recreation, and Fish and Wildlife.

b. Water use contracts: Existing water storage - 38.39 mgd and pending water storage - 50.20 mgd.

c. Interagency agreements: none

d. Informal commitments: none

e. System regulation objectives: The project is operated in a mini-system with Keystone Lake and is regulated to maximize power generation at Keystone and to control floods while retaining equivalent flood control capabilities with Keystone and other projects in the system.

5. Project Evaluation:

a. Effects of impoundment on water stored:

(1) Positive effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(b) Quantity: The lake provides storage for flow augmentation in times of drought.

(2) Negative effects: Due to basin morphometry, the lake stratifies only occasionally and is not associated with water quality degradation.

6. Project Effect on Instream Flows:

(1) General: Discharge duration curves for the natural and modified conditions are attached. The discharge frequency prior to impoundment is attached, however, the project has not been in operation long enough to develop a post impoundment frequency curve. The project is being studied for possible conversion to hydropower.

(2) Positive effects: The low flow durations have increased since impoundment.

(3) Negative effects: Historical water quality data below Kaw Lake is not available, however, the overall water quality is believed to be good. Nitrogen supersaturation may have caused a small fish kill below the dam.

(4) Project effects on system regulation: The project has a significant effect on flood control and navigation on the Arkansas River system.

6. Constraints on Obtaining Instream Quantity and Quality Objectives: The flood control releases are determined by and limited to the requirements specified by the navigation taper needs.

7. Alternatives:

a. Reservoir regulation: none

b. Structural modification: none

c. Storage reallocation: none

d. Other: no action

8. Action Taken to Date: none

9. Planned Action: none

KAW
ARKANSAS, OKLAHOMA AND KANSAS

Top of Conservation (Power) Pool Elevation	1010
Top of Flood Control Pool Elevation	1044.5

OUTLET WORKS

Type	Sluice
Size	2-5.67'x10'
Intake Elevation	940
Control Gates	2-5.67'x10'
Capacity at Conservation Pool (c.f.s.)	6200
Capacity at Flood Control Pool (c.f.s.)	7600

WATER SUPPLY FACILITY

Static Head Pipe	
Diameter	48" Dia.
Elevation	970

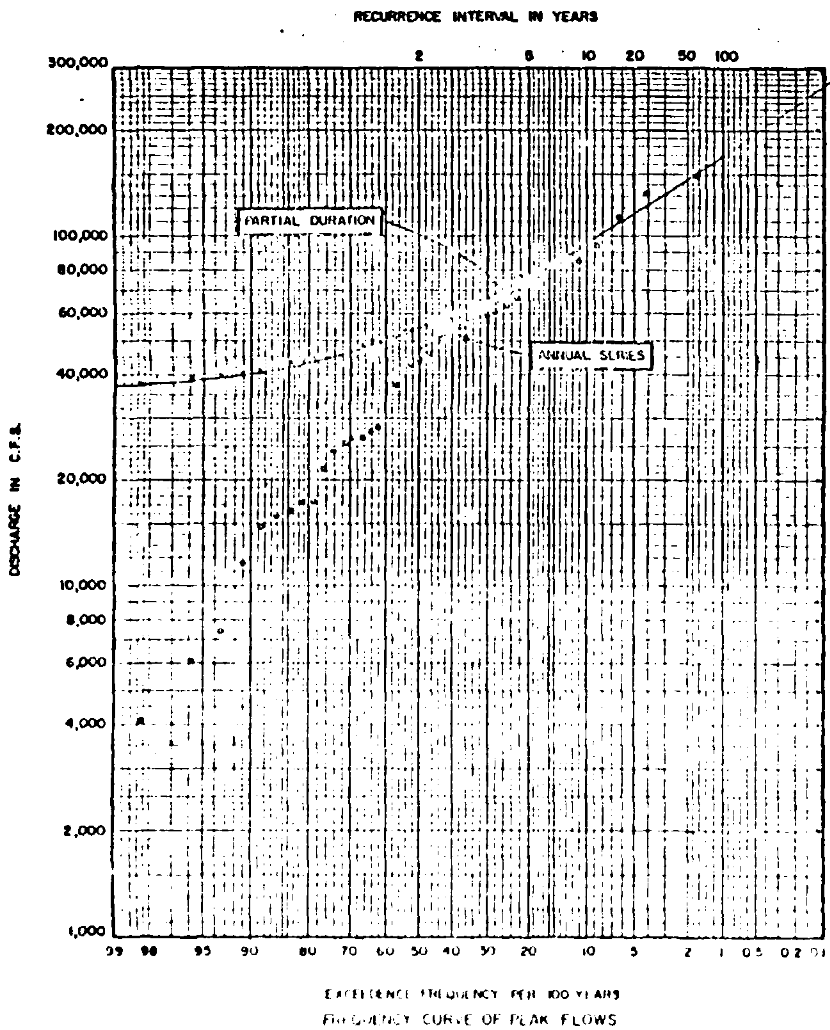
SPILLWAY

Type	Ogee
Crest Width	400'
Crest Elevation	997.5
Control	8-50'x47' (Tainter Gates)
Capacity at Conservation Pool (c.f.s.)	57000
Capacity at Flood Control Pool (c.f.s.)	490,000

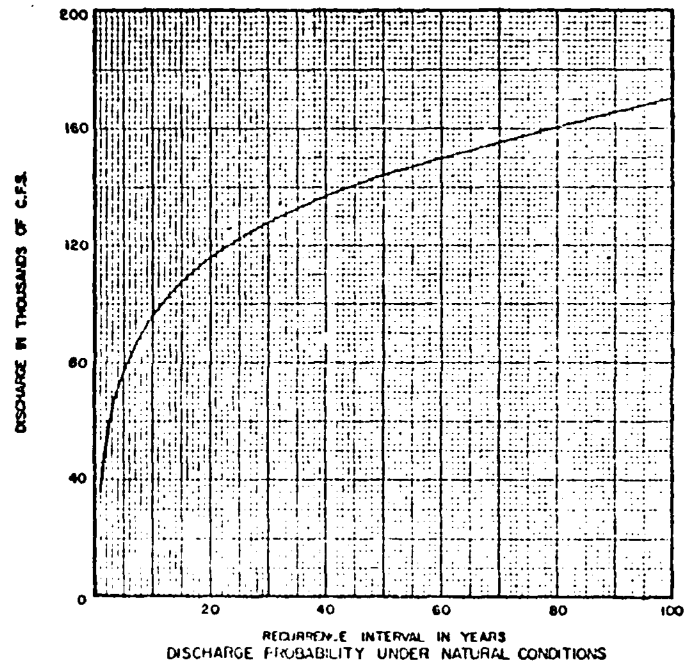
CORPS OF ENGINEERS

NATURAL CONDITIONS

U. S. ARMY



FREQUENCY CURVE OF PEAK FLOWS



DISCHARGE PROBABILITY UNDER NATURAL CONDITIONS

NOTES:
1 BASED ON METHODS OUTLINED IN "STATISTICAL METHODS IN HYDROLOGY" LEO R BEARD, JAN. 1962.
2 BASIC DATA ARE COMPUTED PEAK DISCHARGES AT THE DAM SITE FROM OCTOBER 1921 THROUGH SEPTEMBER 1962

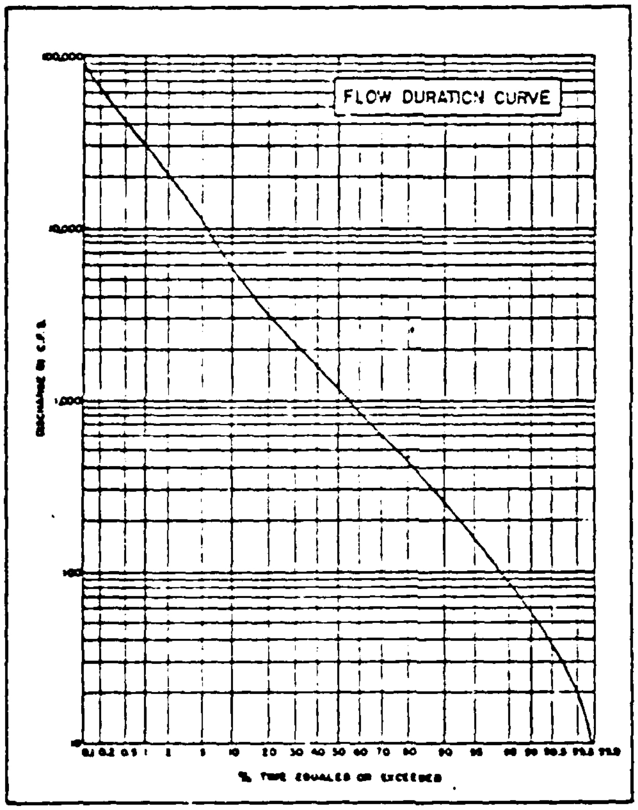
KAW RESERVOIR
ARKANSAS RIVER, OKLAHOMA

PEAK DISCHARGE FREQUENCY CURVES

U S ARMY ENGINEER DIST, TULSA
ENGINEERS SEPT 64
DRAWN R D B

1967

MAX. 148,000
APRIL 24, 1944



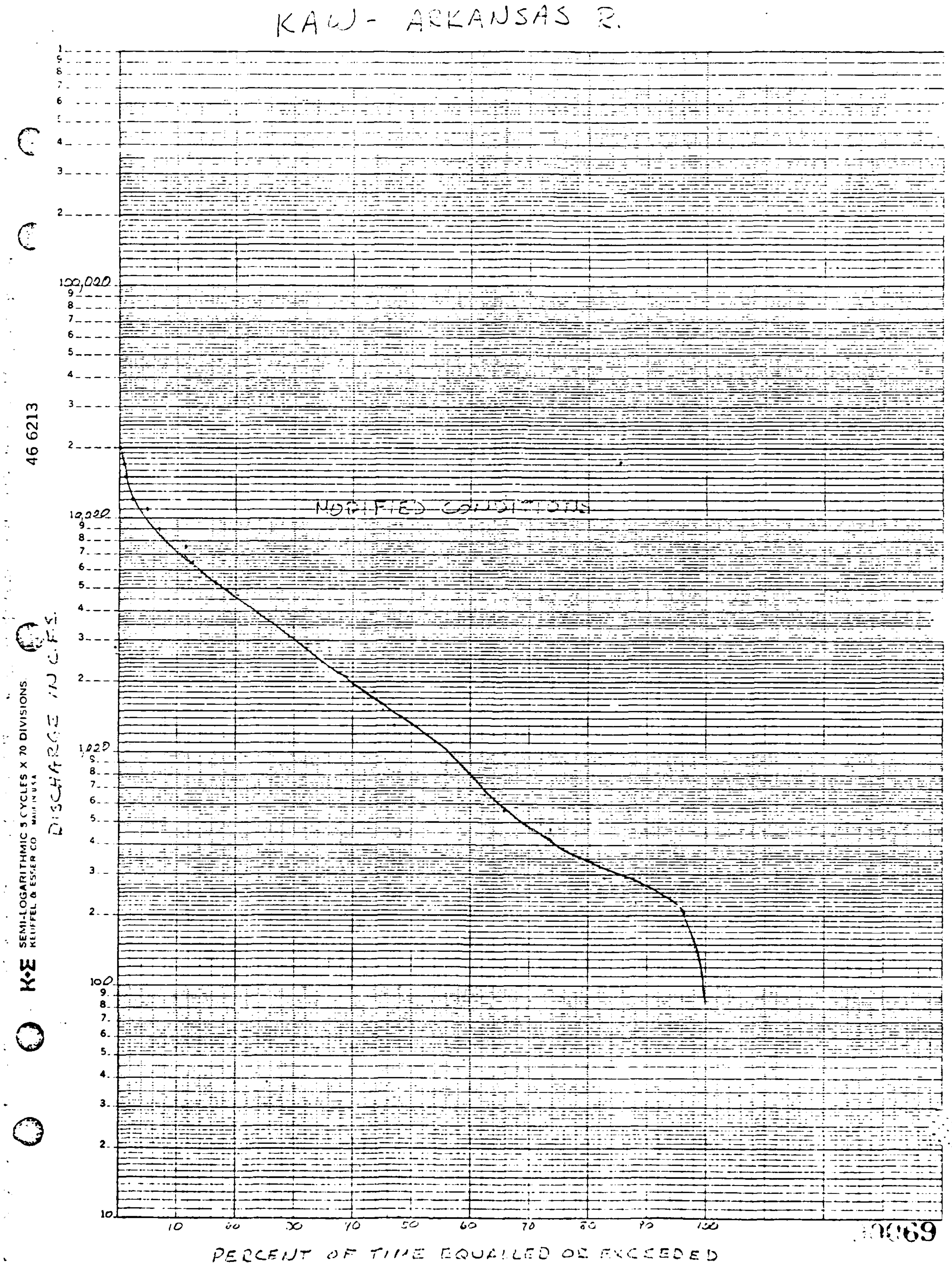
NATURAL CONDITIONS

U.S. ARMY ENGINEER DISTRICT, TULSA
CORPS OF ENGINEERS
TULSA, OKLAHOMA

DESIGNED BY	ARKANSAS RIVER WATERSHED — ARKANSAS RIVER, OKLAHOMA
DRAWN BY	KAW DAM
CHECKED BY	SPILLWAY, 1st. STG. PH. & COMPLETION OF EMB. HYDROLOGY HYDROGRAPHS IV & THIRD & FOURTH STAGE DIVERSION WATER SURFACE ELEVATIONS
SUBMITTED CHIEF, HYDRAULIC BR. DATE DEC. 1970	INVITATION NO. DACW56-71-B-0065 SCALE AS SHOWN DRAWING NO. 1970-C5-99/4

U.S. ARMY C OF E TULSA

00068



KAW - ARKANSAS R.
MODIFIED CONDITIONS
DISCHARGE IN C.F.S.
100,000
10,000
1,000
100
10
10
20
30
40
50
60
70
80
90
100
PERCENT OF TIME EQUALLED OR EXCEEDED
K•E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN USA
46 6213

69

1. Project Name: Great Salt Plains Lake

2. Project Location: River mile 103.3 on Salt Fork of Arkansas River tributary to Arkansas River. Project watershed (3,200 square miles) located in Oklahoma; downstream management control stations located in Oklahoma.

3. Type of Project:

a. General Category: multiple-purpose storage reservoir (excluding hydro-power).

b. Storage Allocations:

	Elevation (feet, N.G.V.D.)	Storage	
		Acre feet	Inches of Runoff
Top Flood Control Pool	1138.5	271,400	1.59
Top Conservation Pool	1125.0	31,420	.18
Bottom Conservation Pool	0	0	0

4. Water Management Criteria:

a. Authorized Project Purpose: flood control and conservation

b. Water Use Contracts: None

c. Interagency Agreements: None

d. Informal Commitments: None

e. System Regulation Objectives: Uncontrolled spillway - no system regulation.

5. Project Evaluation:

a. Effects of impoundment on water stored:

1. Positive effects:

a. Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream. Impoundment provides an important wetland area for wildlife.

b. Negative effects:

a. Quality: Due to the basin morphometry, Great Salt Plains Lake stratifies only occasionally. Such weak and ephemeral stratification is not associated with water quality degradation. During periods of no outflow, the dissolved oxygen in the stilling basin becomes too low to support the fish in the basin area.

3. Cause of negative effects: The increased summer temperatures coupled with a significant oxygen demand leads to low dissolved oxygen levels in the basin when there are no low flow releases.

6. Project Effect on Instream Flows:

1. General: Discharge frequency and duration curves for modified conditions are attached. Natural condition documentation was not available.

2. Negative effects: Historical data from Great Salt Plains tailwater stations were compared to Oklahoma raw water supply standards (see attachments). These drinking water standards were used because Oklahoma has few numerical standards for other water classes. No significant violations of these standards were found.

3. Project effects on system regulation: The project provides a major flood controlling capability on the Salt Fork of Arkansas River but only a minor impact on the Arkansas River System.

7. Constraints on Obtaining Instream Quantity and Quality Objectives: Water quality releases were not authorized as a project purpose.

8. Alternatives:

a. Reservoir Regulations: Providing for some low flow releases for the purpose of aerating the stilling basin would maintain the fishery in that area.

b. Structural Modification: None

c. Storage Reallocation: Some storage needs to be allocated to allow for a low flow release (6 cfs) which would maintain dissolved oxygen levels in the basin.

d. Other: Aeration by air-bubbling or oxygen injection would alleviate the low dissolved oxygen problem.

e. No Action.

9. Action Taken to Date: Successful tests have been conducted to maintain sufficient dissolved oxygen levels for fish in the basin. A release of 6 cfs has been sufficient.

10. Planned Action: A regulation change will be proposed to make a 6 cfs release from Great Salt Plains to maintain the fishery in the basin during summer periods of no spillway releases.

GREAT SALT PLAINS
SALT FORK OF ARKANSAS RIVER, OKLAHOMA

Top of Conservation (Power) Pool Elevation	1125
Top of Flood Control Pool Elevation	1138.5

OUTLET WORKS

Type	Sluice
Size	4-10'x12'
Intake Elevation	1105
Control	Intermediate Weir @ EL. 1125
Capacity at Conservation Pool (c.f.s.)	0

WATER SUPPLY FACILITY

Low Flow	
Type	Pipe
Size	2-36" Dia.
Elevation	1110
Capacity at Conservation Pool (c.f.s.)	360

SPILLWAY

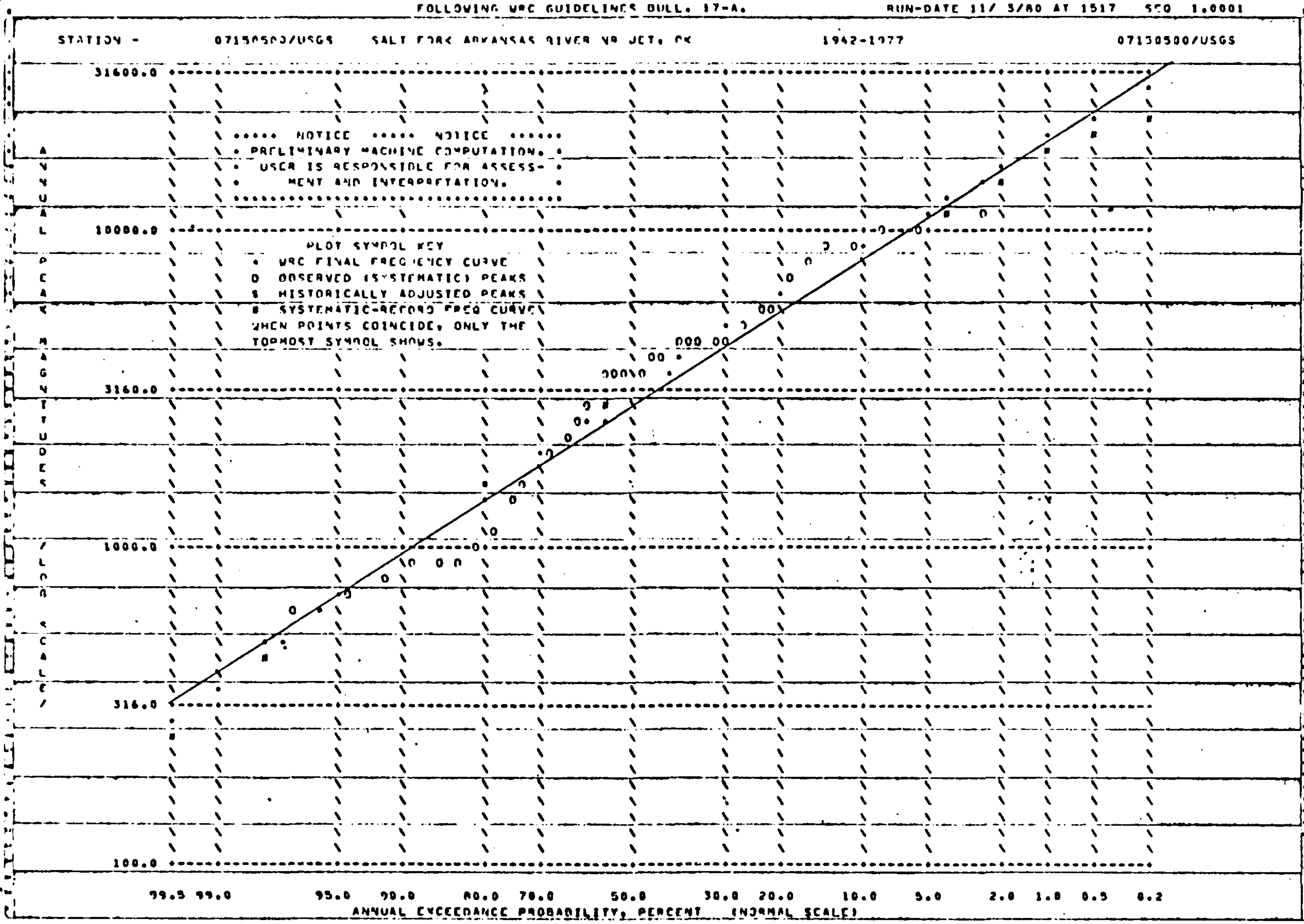
Type	Ogee (3-Stage)
Crest Width	3101
Crest Elevation	1110
Control	Uncon
Capacity at Conservation Pool (c.f.s.)	0
Capacity at Flood Control Pool (c.f.s.)	13,500

GREAT SALT PLAINS

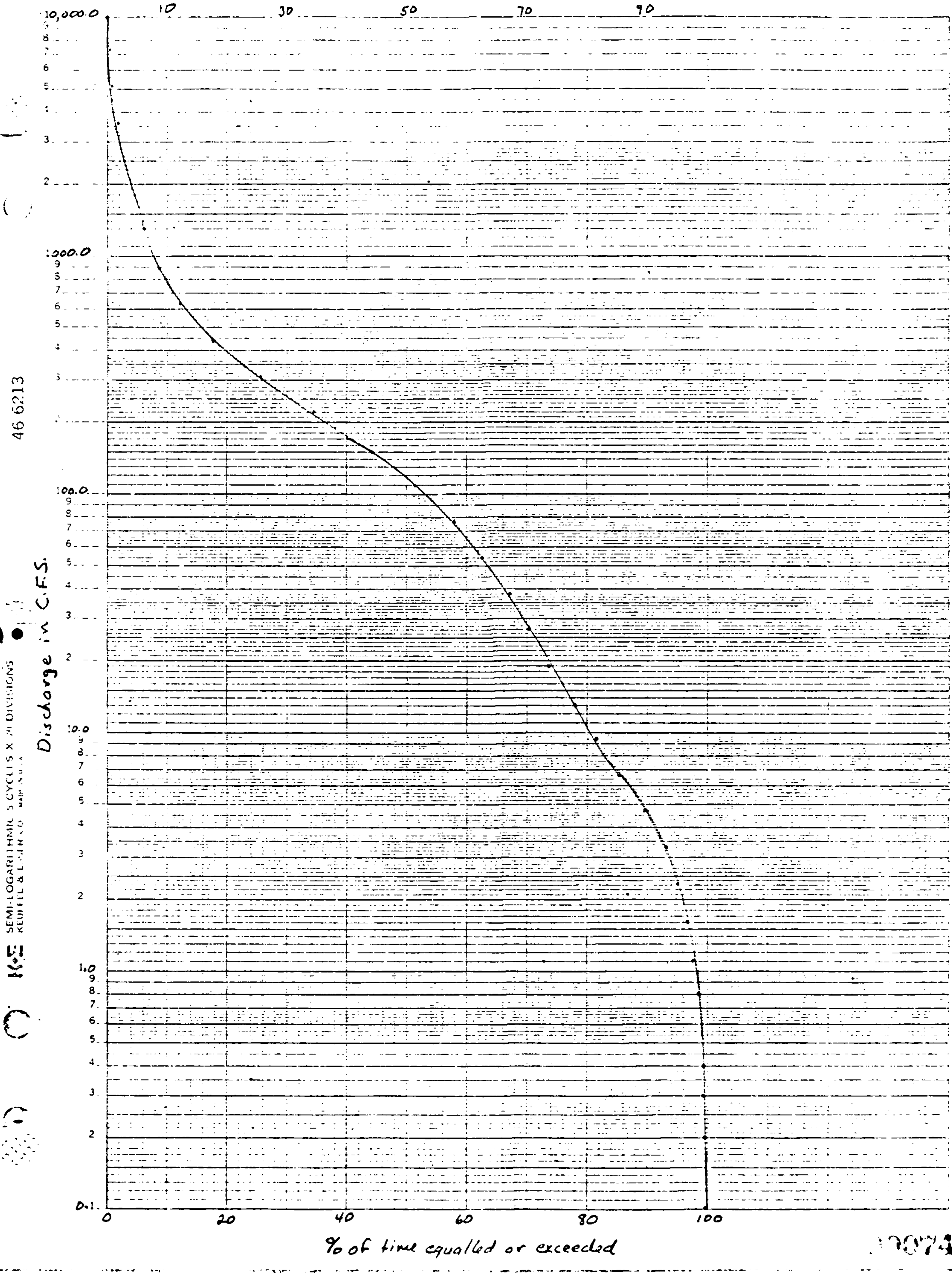
PGM J407 VER 3.4
(REV 10/22/79)

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 3/80 AT 1517 SEQ 1.0001



GSP - Salt Fork Ark. R. near Jet



00074

STORET RETRIEVAL DATE 80/10/10 - STAND - VERSION OF SEP. 198 STN 1.SUMMARY.1
NC DATA MILES BELOW GSP

7150500
45 11.0 C58 07 44.0 2
SALT FORK ARKANSAS RIVER NR JET, OK
40003 OKLAHOMA ALFALFA
100291

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 52/10/15 TO 80/04/05

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	239	0	11	0	11	11	11	44	42	0
MEAN	16.60	0.0	5.00	0.	8.364	24.45	18.	11.386	0.470	0.0
MEDIAN	17.00	0.0	4.00	0.	7.000	10.00	12.	10.850	0.395	0.0
NO OF VIOLS	6	0	0	0	3	2	0	1	1	0
PERCENT VIOL	3.	0.	0.	0.	27.	18.	0.	2.	2.	0.
MINIMUM VIOL	33.00	0.0	0.0	0.	13.000	69.00	0.	4.600	5.000	0.0
MEAN VIOL	36.82	0.0	0.0	0.	18.000	70.00	0.	4.600	5.000	0.0
MAXIMUM VIOL	46.00	0.0	0.0	0.	25.000	71.00	0.	4.600	5.000	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

0075

WQ DATA 0.6 MILES BELOW GSP

07150500
36 45 11.0 098 07 44.0 2
SALT FORK ARKANSAS RIVER NR JET, OK
40003 OKLAHOMA ALFALFA
100291

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 52/10/15 TO 80/04/05

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	11	0	9	0	638	638	9	11	10	33
MEAN	31.73	0.0	0.511	0.0	8.016	8.016	2.222	7.73	14.	34.59
MEDIAN	30.00	0.0	0.500	0.0	7.900	7.900	2.000	6.00	14.	30.00
NO OF VIOLS	2	0	0	0	2	4	0	0	0	5
PERCENT VIOL	18.	0.	0.	0.	0.	1.	0.	0.	0.	15.
MINIMUM VIOL	53.00	0.0	0.0	0.0	9.800	6.400	0.0	0.0	0.	64.00
MEAN VIOL	56.50	0.0	0.0	0.0	72.400	6.475	0.0	0.0	0.	98.00
MAXIMUM VIOL	60.00	0.0	0.0	0.0	135.000	6.500	0.0	0.0	0.	180.00
MIN CRITERIA	*********	*********	*********	*********	*********	6.500	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	9.000	*********	10.000	50.00	5000.	50.00

00076

1. Project Name: Keystone Lake

2. Project Location: River Mile 538.8 on Arkansas River. Project watershed (22,351 square miles) located in Oklahoma; downstream management control stations located in Oklahoma and Arkansas.

3. Type of Project:

a. General Category: Multiple-purpose storage reservoir (including hydropower)

b. Storage Allocations:

	Elevation Feet (N.G.V.D.)	Storage	
		Acre-Feet	Inches Runoff
Top Flood Control Pool	754.0	1,836,500	1.54
Top Conservation Pool	723.0	618,000	.52
Bottom Conservation Pool	706.0	287,500	.24
Water Supply Storage (20 mgd)		20,000	

c. Hydropower Category: Run-of-river

4. Water Management Criteria:

a. Authorized Project Purpose: Flood control, water supply, navigation, hydropower and fish and wildlife

b. Water Use Contracts: Water storage 18 mgd; water withdrawal 0.44 mgd.

c. Interagency Agreements: SPA markets power

d. Informal Commitments:

(1) With KRMG Radio to make releases for a raft race each Labor Day.

(2) With SPA to provide an additional one-foot of water in the lake to make power releases for the raft race instead of the Corps making gated releases.

(3) With SPA to provide power releases for downstream water quality at least once every two days.

e. System Regulation Objectives: The project is regulated in the system to maximize power generation and to control floods while retaining equivalent flood control capabilities with other projects in the system. Also the project is operated as a mini-system with Kaw Lake.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with the storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(b) Quantity: The lake provides storage for flow augmentation in times of drought.

(2) Negative effects:

(a) Quality: Keystone Lake becomes thermally stratified from early summer through mid-fall. Due to differences in dissolved solids content of the principle feeder rivers, various parts of the lake stratify by density. Chemical reactions within the anoxic hypolimnion cause an increase in dissolved iron and manganese within this zone. The water in the hypolimnion decreases in pH and temperature while ammonia and hydrogen sulfide levels are elevated. When the lake returns to complete mixing in the fall, the water quality becomes more desirable.

(b) Quantity: Power generation causes tailwater fluctuations to be greater than normal.

(3) Cause of negative effects: Soils within the watershed are high in iron and manganese. Agricultural operations lead to large input of these soils to the lake. Additionally, the Cimarron River contains high levels of total dissolved solids which leads to the formation of haloclines.

b. Project Effect on Instream Flows:

(1) General: Discharge frequency and duration curves for the natural and modified conditions are attached.

(2) Positive effects: The magnitude of peak discharges have been reduced. Releases of 100 to 1,500 cfs have increased in duration.

(3) Negative effects: Historical data from Keystone tailwater stations were compared to Oklahoma Raw Water Supply Standards (see attachments). These drinking water standards were used because Oklahoma has few numerical standards for other water classes. Few violations of temperature or dissolved oxygen were found, although these are probably more frequent closer to the stilling basin. High levels of lead and dissolved manganese were noted.

(4) Cause of negative effects: Water withdrawn from the hypolimnion for power generation is anoxic. Turbulence from the release is apparently sufficient to allow this water to meet State DO standards at a point 5 miles downstream. The manganese violations are caused by high levels of this metal in watershed soils and chemical cycling in the hypolimnion. No explanation is available for elevated lead content, but is appears the majority of the samples were analyzed using a method with a detection limit of 100 ug/l. The values were probably entered as less than 100 ug/l.

c. Project Effects on System Regulations. The project has a major effect on the flood controlling capabilities and on navigation in the Arkansas River system.

6. Constraints on Obtaining Instream Quantity and Quality Objectives: Unable to make selective water level withdrawals for downstream releases. The flood control and power releases are determined by and limited to the requirements specified by the navigation taper needs.

7. Alternatives:

a. Reservoir Regulation: Providing for a low flow release of 50 cfs would insure satisfactory dissolved oxygen levels are maintained for fish in the basin.

b. Structural Modification: A selective withdrawal system for generation releases would improve the quality of the releases.

c. Storage Reallocation: None

d. Other: Destratification of the main body would improve the quality of generation releases.

e. No action.

8. Action Taken To Date: Studies have been performed to determine the oxygen uptake of the river below Keystone.

9. Planned Action: Problem documentation and other studies are planned.

KEYSTONE
ARKANSAS RIVER, OKLAHOMA

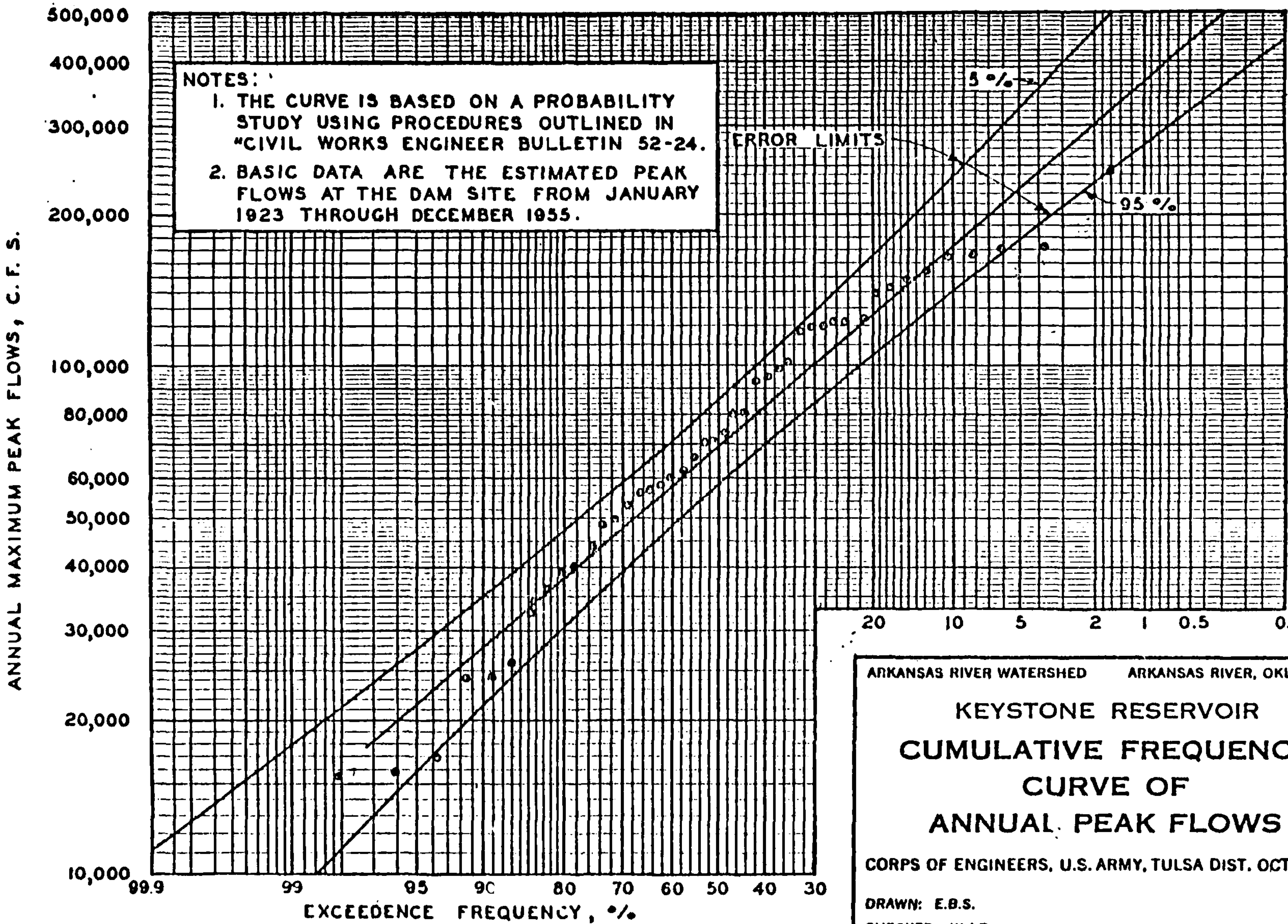
Top of Conservation (Power) Pool Elevation	723 (Power)	
Top of Flood Control Pool Elevation	754	

OUTLET WORKS

Type	Sluice	Penstock
Size	9-5.67'x10'	2-27' Dia.
Intake Elevation	657	659.5
Control Gates	9-5.67'x10'	2-14'x30'
Capacity at Conservation Pool (c.f.s.)	28,900	
Capacity at Flood Control Pool (c.f.s.)	34,000	

SPILLWAY

Type	Ogee
Crest Width	720'
Crest Elevation	719
Control	18-40'x35' (Tainter Gates)
Capacity at Conservation Pool (c.f.s.)	18,000
Capacity at Flood Control Pool (c.f.s.)	565,200



ARKANSAS RIVER WATERSHED — ARKANSAS RIVER, OKLAHOMA

KEYSTONE RESERVOIR

CUMULATIVE FREQUENCY CURVE OF ANNUAL PEAK FLOWS

CORPS OF ENGINEERS, U.S. ARMY, TULSA DIST. OCT. 1956

DRAWN: E.B.S.
CHECKED: W.J.B.

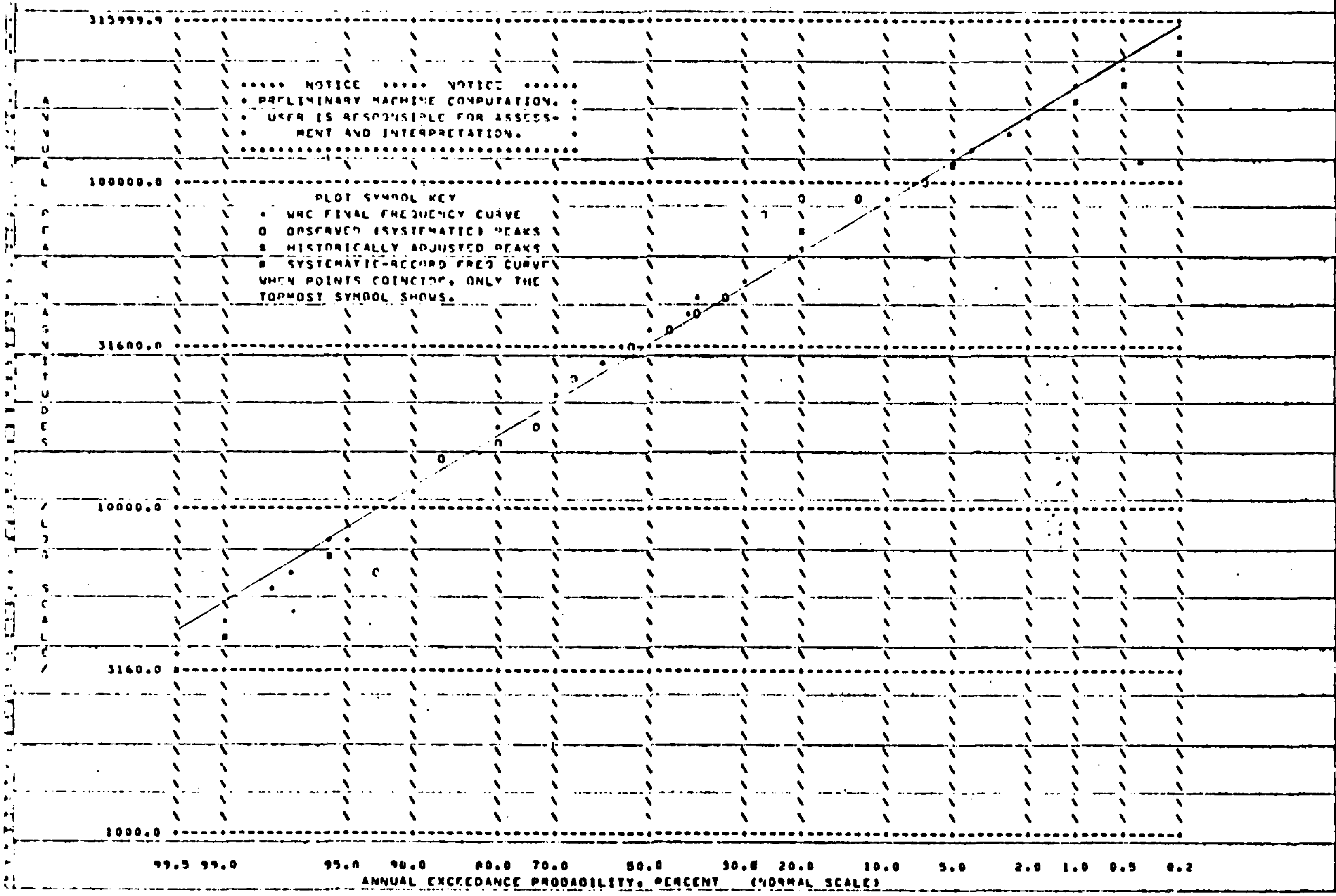
KEYSTONE

PGM J407 VER 3.4
(REV 10/22/79)

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

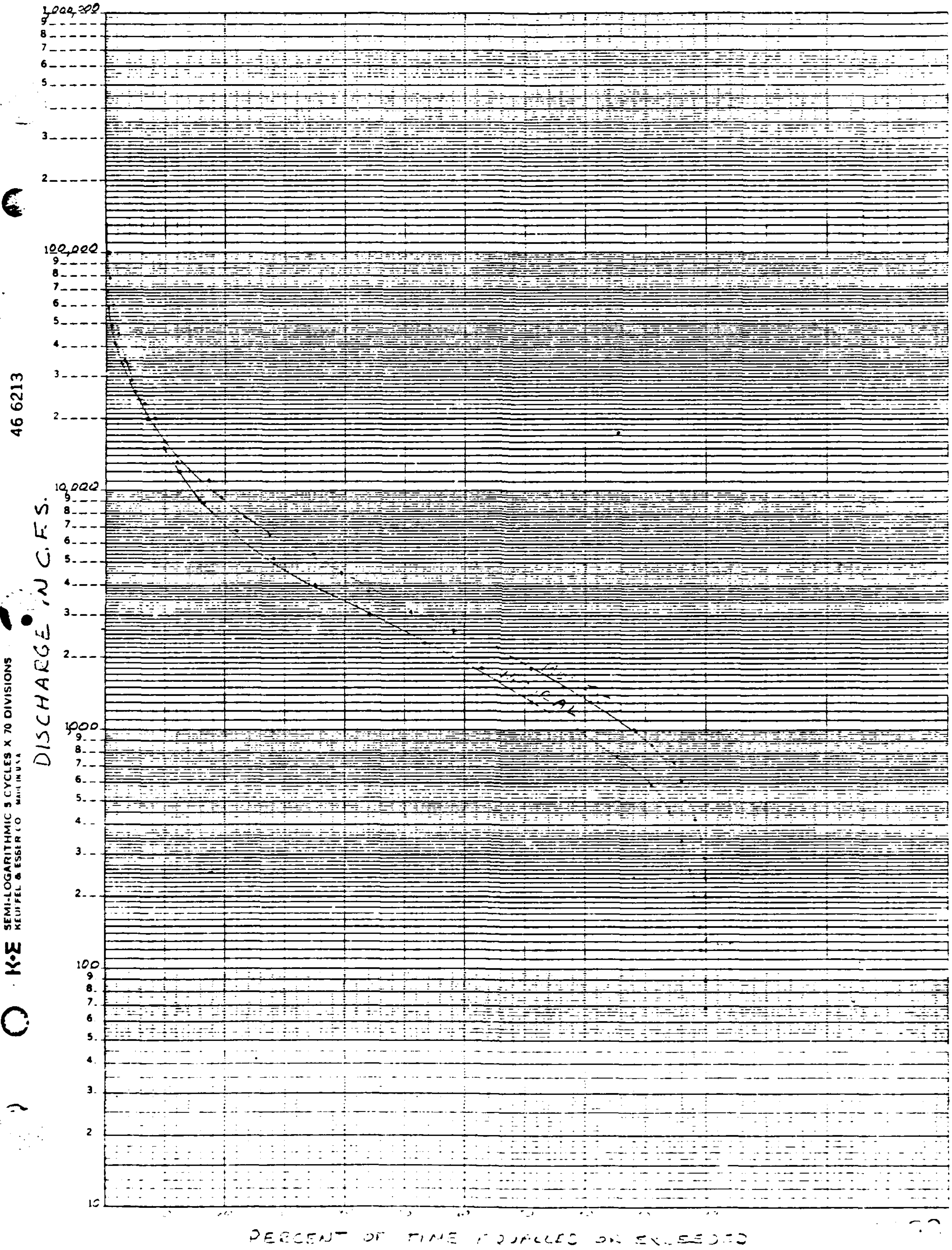
FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 3/80 AT 1537 SEQ 1.0001

STATION - 07164500/USGS ARKANSAS RIVER AT TULSA, OK 1964-1977 07164500/USGS



0082

KEYSTONE- ARKANSAS R.



STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980

STN 1.SUMMARY.1

43 DATA 5 MILES BELOW KEYSTONE

07164400
36 06 48.0 096 06 49.0 2
ARKANSAS RIVER AT SAND SPRINGS N
40143 OKLAHOMA
100992

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 68/08/20 TO 77/03/15

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	213	43	48	0	48	47	10	126	0	0
MEAN	16.18	0.131	2.92	0.	9.583	4.53	16.	9.494	0.0	0.0
MEDIAN	16.00	0.080	3.00	0.	10.000	0.0	10.	9.250	0.0	0.0
NO OF VIOLS	0	1	0	0	1	0	0	1	0.	0
PERCENT VIOL	0.	2.	0.	0.	2.	0.	0.	1.	0.	0.
MINIMUM VIOL	0.0	0.880	0.0	0.	20.000	0.0	0.	4.600	0.0	0.0
MEAN VIOL	0.0	0.880	0.0	0.	20.000	0.0	0.	4.600	0.0	0.0
MAXIMUM VIOL	0.0	0.880	0.0	0.	20.000	0.0	0.	4.600	0.0	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

STORET R[illegible]VAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980

STN 1.SUMMARY.2

[illegible] DATA S[illegible] [illegible]ES BELOW KEYSTONE

[illegible]164400
36 06 48.0 096 06 49.0 2
ARKANSAS RIVER AT SAND SPRINGS V
40143 OKLAHOMA
100992

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

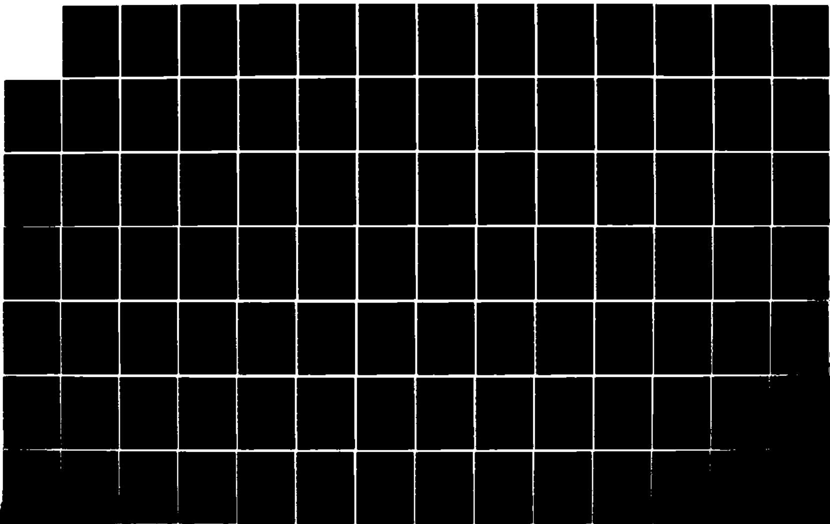
SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 68/08/20 TO 77/03/15

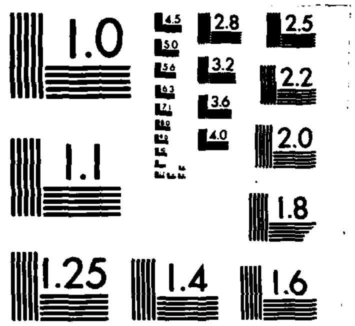
	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	48	10	44	0	398	398	10	6	46	58
MEAN	95.83	77.00	0.143	0.0	8.118	8.118	0.700	2.83	61.	26.71
MEDIAN	100.00	80.00	0.100	0.0	8.100	8.100	1.000	2.50	40.	10.00
NO OF VIOLS	46	7	0	0	1	5	0	0	0	4
PERCENT VIOL	96.	70.	0.	0.	0.	1.	0.	0.	0.	7.
MINIMUM VIOL	100.00	70.00	0.0	0.0	6.500	9.100	0.0	0.0	0.	76.00
MEAN VIOL	100.00	94.29	0.0	0.0	6.500	9.260	0.0	0.0	0.	179.00
MAXIMUM VIOL	100.00	130.00	0.0	0.0	6.500	9.400	0.0	0.0	0.	240.00
MIN CRITERIA	*********	*********	*********	*********	6.500	*********	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10,000	*********	9.000	10.000	50.00	5000.	50.00

[illegible]055

AD-A156 496 RESERVOIR CONTROL CENTER: ACTIVITIES AND ACCOMPLISHMENTS OF THE SOUTHWEST..(U) CORPS OF ENGINEERS DALLAS TX SOUTHWESTERN DIV JAN 81 2/6

UNCLASSIFIED F/G 13/2 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

1. Project Name: Heyburn Lake

2. Project Location: River mile 48.6 on Polecut Creek tributary to Arkansas River. Project watershed (123 square miles) located in Oklahoma; downstream management control stations located in Oklahoma.

3. Type of Project:

a. General Category: multiple-purpose storage reservoir (excluding hydropower).

b. Storage Allocations:

	Elevation (Feet N.G.V.D.)	Storage Acre-Feet	Storage Inches Runoff
Top Flood Control Pool	784.0	55,030	8.39
Top Conservation Pool	761.5	6,620	1.01
Bottom Conservation Pool	755.5	2,820	.43
Water Supply Storage (1.7 mgd)		1,900	

4. Water Management Criteria:

a. Authorized Project Purpose: flood control and conservation.

b. Water Use Contracts: Water storage 1.7 mgd.

c. Interagency Agreements: None

d. Informal Commitments: None

e. System Regulation Objectives: Regulated in the system to control floods and retain equivalent flood control capabilities with other projects in the system.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive Effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with strom runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(2) Negative Effects:

(a) Quality: Due to the basin morphometry, Heyburn Lake stratifies only occasionally. Such weak and ephemeral stratification is not associated with water quality degradation.

b. Project Effect on Instream Flows:

(1) General: Discharge frequency and duration curves for both the natural and modified conditions are attached.

(2) Positive Effects: Peak discharge magnitude have been reduced.

(3) Negative Effects: Little historical water quality data are available for the Heyburn tailwater (see attachments). Available data show few violations of Oklahoma pH and dissolved oxygen standards. However, since no outflow is maintained, dissolved oxygen is known to approach zero within the stilling basin at times. This has led to fishkills similar to natural deep pools during dry weather. Flows below 2 to 3 cfs have been reduced in duration.

(4) Cause of Negative Effects: Lack of permanent low flow during summer months, warm water temperatures, and significant oxygen demands cause the low dissolved oxygen levels.

c. Project Effects on System Regualtion: The project has an insignificant effect on flood control in the Arkansas River system.

6. Constraints on Obtaining Instream Quanity and Quality Objectives: Water quality releases were not authorized as a project purpose.

7. Alternatives:

a. Reservoir Regulation: Providing for some low flow releases for the purpose of aerating the stilling basin would maintain the fishery in that area.

b. Structural Modification: None

c. Storage Reallocation: Some storage needs to be allocated to allow for a low flow release (2 cfs) which would maintain dissolved oxygen levels in the basin.

d. Other: ~~De~~Aeration by air bubbling or oxygen injection would alleviate the low dissoved oxygen problem.

e. No action.

8. Action Taken to Date: Successful tests have been conducted to maintain sufficient dissolved oxygen levels for fish in the basin. A 1 to 2 cfs release was sufficient. Installation of an aerator has also been investigated.

9. Planned Action: None.

HEYBURN
POLECAT CREEK, OKLAHOMA

Top of Conservation (Power) Pool Elevation	761.5
Top of Flood Control Pool Elevation	784

OUTLET WORKS

Type	Conduit(Drop Inlet)
Size	8.25' Dia.
Intake Elevation	761.5
Control Gates	None
Capacity at Conservation Pool (c.f.s.)	0
Capacity at Flood Control Pool (c.f.s.)	2040

WATER SUPPLY FACILITY

Low Flow	
Type	Pipe
Size	3-36" Dia.
Elevation	740
Capacity at Conservation Pool (c.f.s.)	640
Static Head Pipe	
Diameter	24" Dia.
Elevation	741.5

SPILLWAY

Type	Excavated
Crest Width	200'
Crest Elevation	784
Control	Uncon
Capacity at Conservation Pool (c.f.s.)	0
Capacity at Flood Control Pool (c.f.s.)	0

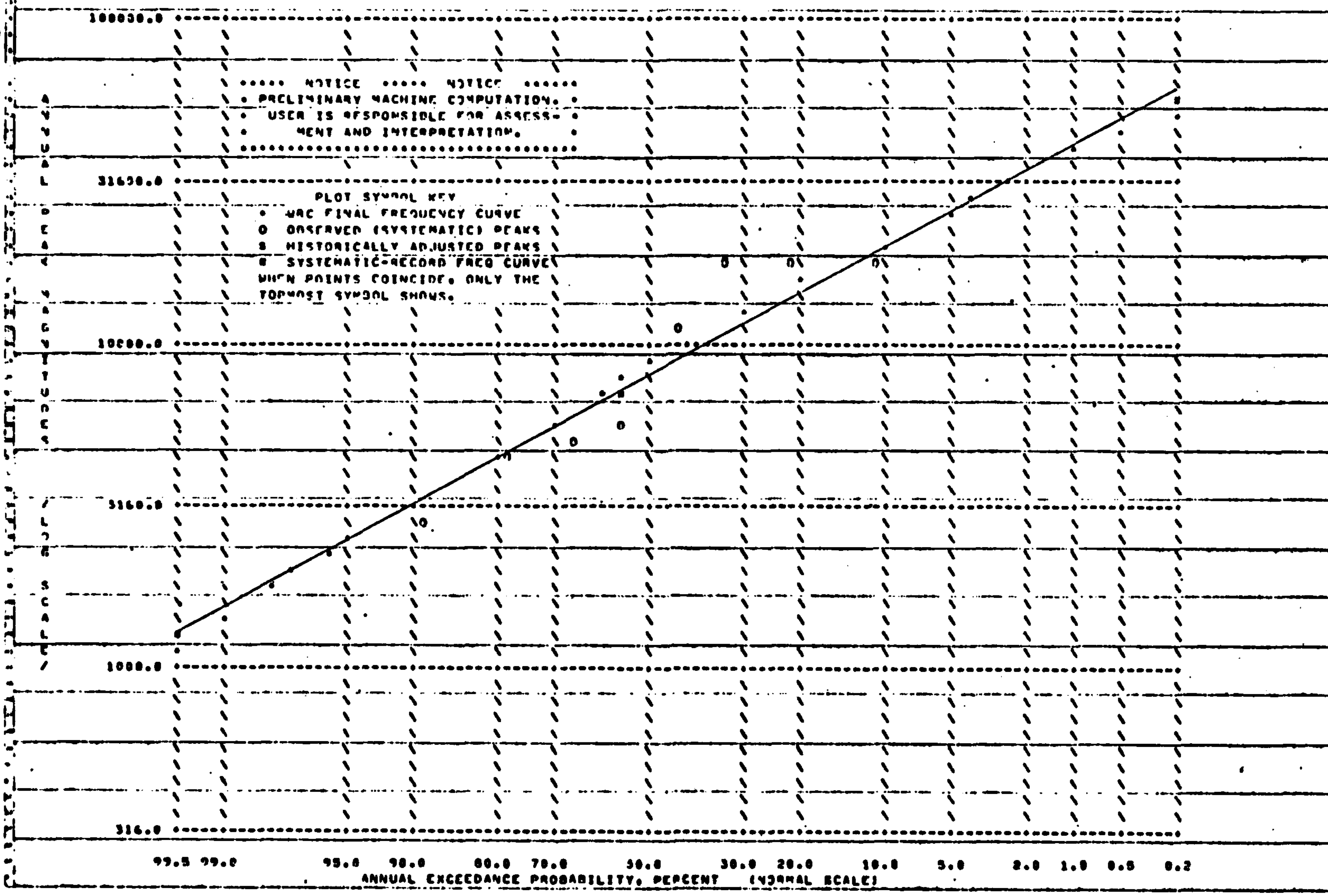
HEYBURN -ORIG.

PGM J407 VER 3.4
(REV 10/22/79)

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 4/80 AT 1123 SEQ 1.0001

STATION - 07165500/USGS POLECAT CREEK BLW HEYBURN RES NEAR HEYBURN, OK 1940-1977 07165500/USGS



68D[illegible]

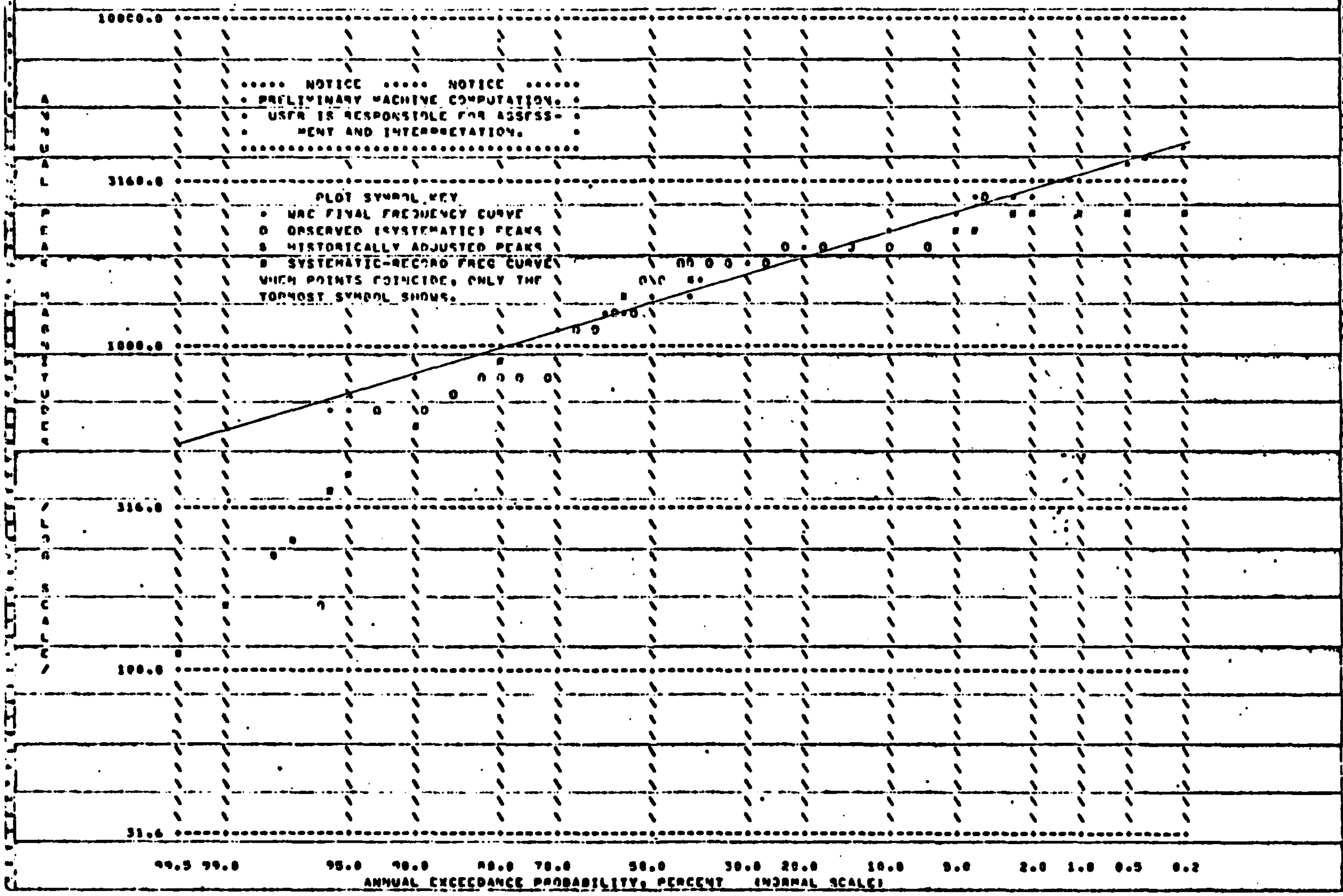
HEYBURN

WSM J407 VER 3.4
(REV 10/22/79)

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

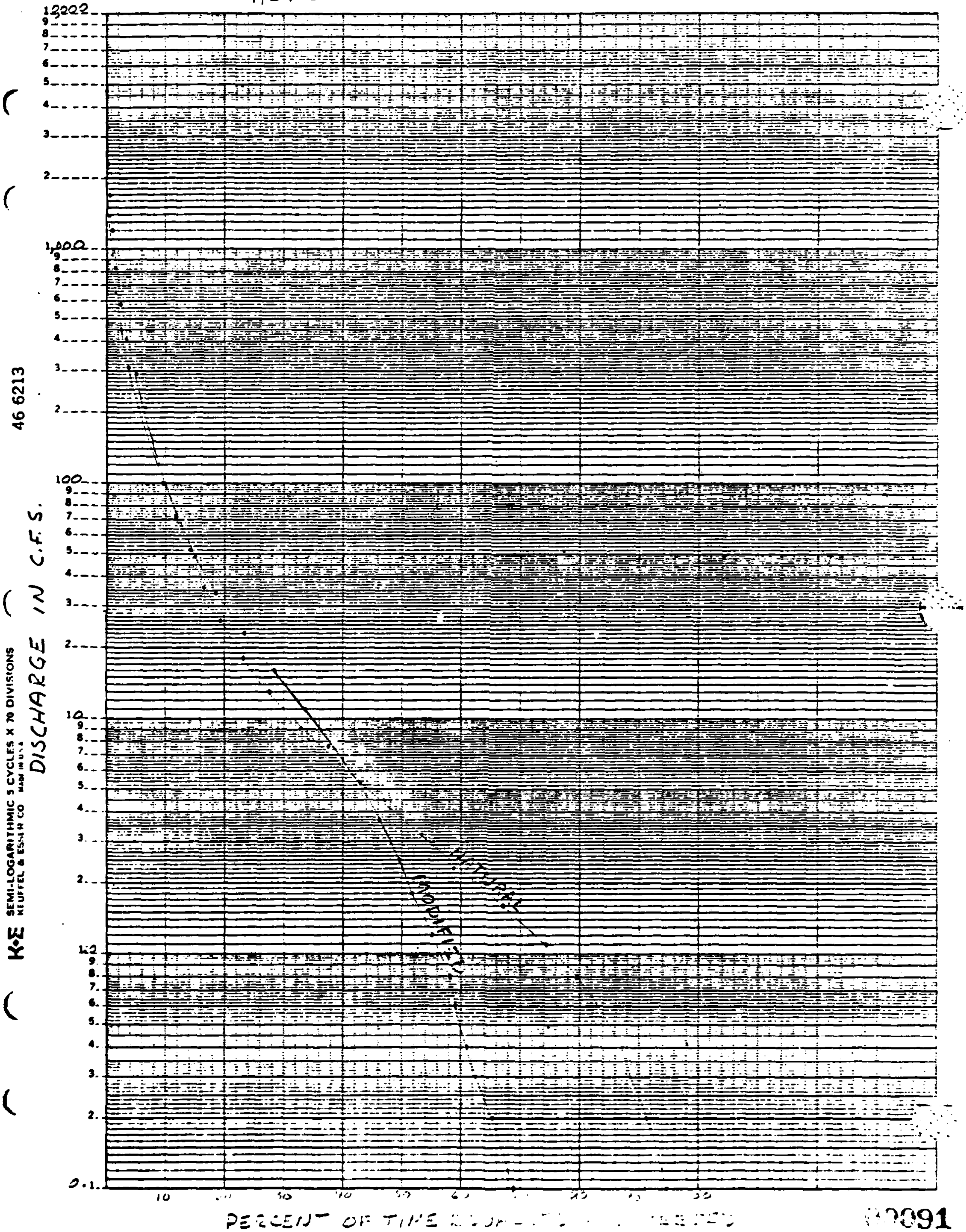
FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 3/80 AT 1510 SEQ 1.0001

STATION - 07165500/USGS POLECAT CREEK BLW HEYBURN RES NEAR HEYBURN, OK 1950-1977 07165500/USGS



00090

HEYBURN - POLECAT CK.



STORET RETRIEVAL DATE 80/10/10 - STAND - VERSION OF SEP. 1980 STN 1.SUMMARY.1

NO DATA 0.2 MILES BELOW HEYBURN

07165500
35 56 42.0 096 17 29.0 2
POLECAT CREEK BLW HEYBURN RES NE
40037 OKLAHOMA
100992

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

00092

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 52/01/07 TO 78/05/23

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	22	0	0	0	0	0	0	0	0	0
MEAN	13.23	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MEDIAN	11.00	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
NO OF VIOLS	1	0	0	0	0	0	0	0	0	0
PERCENT VIOL	5.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MINIMUM VIOL	36.50	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MEAN VIOL	36.50	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MAXIMUM VIOL	36.50	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

STORET R[illegible]EVAL DATE 80/10/10 - STAND - VERSION OF SEP. 19[illegible]
WQ DATA, MILES BELOW HEYBURN

STN 1.SUMMARY.2

00093

7165500
35 56 42.0 096 17 39.0 2
POLECAT CREEK BLW HEYBURN RES NE
40037 OKLAHOMA
100992

/TYPA/AMENT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 52/01/07 TO 78/05/23

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	C1077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	0	0	0	0	26	26	0	0	0	0
MEAN	0.0	0.0	0.0	0.0	7.115	7.115	0.0	0.0	0.	0.0
MEDIAN	0.0	0.0	0.0	0.0	7.150	7.150	0.0	0.0	0.	0.0
NO OF VIOLS	0	0	0	0	0	5	0	0	0	0
PERCENT VIOL	0.	0.	0.	0.	0.	19.	0.	0.	0.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.0	0.0	6.100	0.0	0.0	0.	0.0
MEAN VIOL	0.0	0.0	0.0	0.0	0.0	6.360	0.0	0.0	0.	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.0	0.0	6.500	0.0	0.0	0.	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	6.500	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	9.000	*********	10.000	50.00	5000.	50.00

1. Project Name: Toronto Lake

2. Project Location: River mile 271.5 on Verdigris River tributary to Arkansas. Project watershed (730 square miles) located in Kansas; downstream management control stations located in Kansas.

3. Type of Project:

a. General Category: multiple-purpose storage reservoir (excluding hydropower).

b. Storage Allocations:

	Elevation (feet,N.G.V.D.)	Storage Acre-feet	Storage Inches of Runoff
Top Flood Control Pool	931.0	199,700	5.13
Top Conservation Pool	901.5	21,890	.56
Bottom Conservation Pool	896.7	11,100	.28
Water Supply Storage (.1 mgd)		400	
Water Quality Storage (3.2 mgd)		10,300	

4. Water Management Criteria:

a. Authorized Project Purposes: flood control and conservation

b. Water Use Contracts: Water storage - 0.08 mgd

c. Interagency Agreements: None

d. Informal Commitments: None

e. System Regulation Objectives: The project is regulated as a system with Elk City and Fall River to retain equivalent flood control capabilities and total combined releases and local flows are not to exceed 20,000 cfs at Independence, Kansas and 30,000 cfs at Lenapah, Oklahoma.

5. Project Evaluation:

a. Effects of impoundments on water stored:

1. Positive effects:

a. Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

b. Quantity: The lake provides storage for flow augmentation in times of drought.

2. Negative effects:

a. Quality: Due to the basin morphometry, Toronto Lake stratifies only occasionally. Such weak and ephemeral stratification is not associated with water quality degradation.

b. Quantity: The lake is operated under a water level management plan aimed at enhancing the fishery. This can cause tailwater fluctuations to be greater than normal.

6. Project Effect on Instream Flows:

1. General: Discharge frequency and duration curves for natural and modified conditions are attached.

2. Positive effects: The peak flow magnitudes have been reduced and the low flow durations have been increased.

3. Negative effects: Historical data from Toronto tailwater stations were compared to Kansas Class A water quality standards (see attachments). No significant violations of these standards were found, however, no data were available for many parameters.

4. Project effects on system regulation: The project has significant flood control effects on the Verdigris River.

7. Alternatives:

a. Reservoir Regulation: None

b. Structural Modification: None

c. Storage Reallocation: None

d. Other: None

8. Action Taken to Date: None

9. Planned Action: None

TORONTO
VERDIGRIS RIVER, KANSAS

Top of Conservation (Power) Pool Elevation	901.5
Top of Flood Control Pool Elevation	931.0

OUTLET WORKS

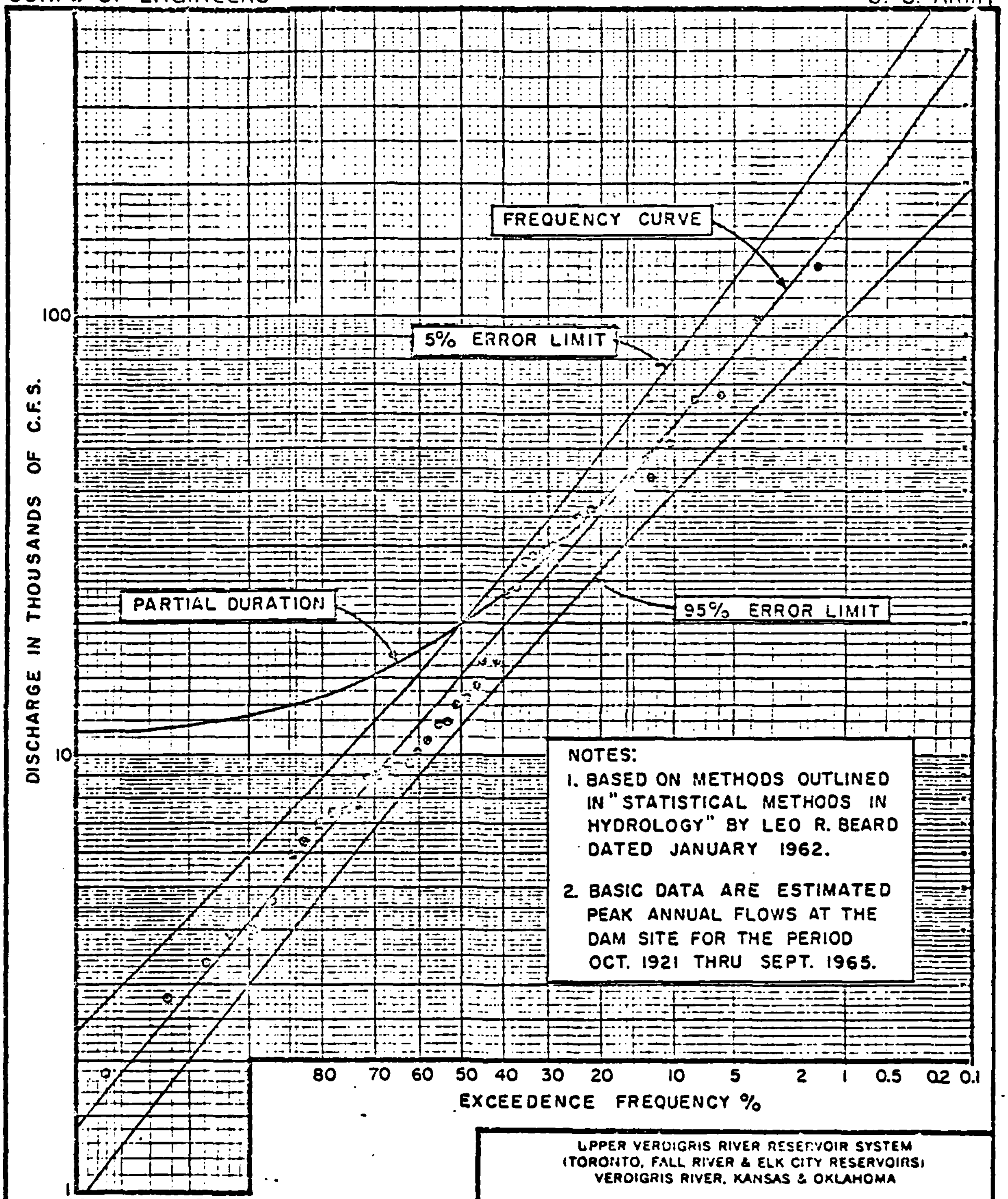
Type	Sluice
Size	7-5'x6.5'
Intake Elevation	870.0
Control Gates	7-5'x6.5'
Capacity at Conservation Pool (c.f.s.)	7400
Capacity at Flood Control Pool (c.f.s.)	10,150

WATER SUPPLY FACILITY

Low Flow	
Type	Pipe
Size	24" Dia.
Elevation	878.5
Capacity at Conservation Pool (c.f.s.)	79

SPILLWAY

Type	Ogee
Crest Width	320'
Crest Elevation	906.0
Control	8-40'x25' (Tainter Gates)
Capacity at Conservation Pool (c.f.s.)	0
Capacity at Flood Control Pool (c.f.s.)	148,000



UPPER VERDIGRIS RIVER RESERVOIR SYSTEM
(TORONTO, FALL RIVER & ELK CITY RESERVOIRS)
VERDIGRIS RIVER, KANSAS & OKLAHOMA

TORONTO RESERVOIR

VERDIGRIS RIVER, KANSAS

CUMULATIVE FREQUENCY CURVE OF ANNUAL PEAK FLOWS

U. S. ARMY ENGINEER DIST., TULSA, CORPS OF ENGINEERS FEB 66
DRAWN: C.E.S.
CHECKED D.R.H.

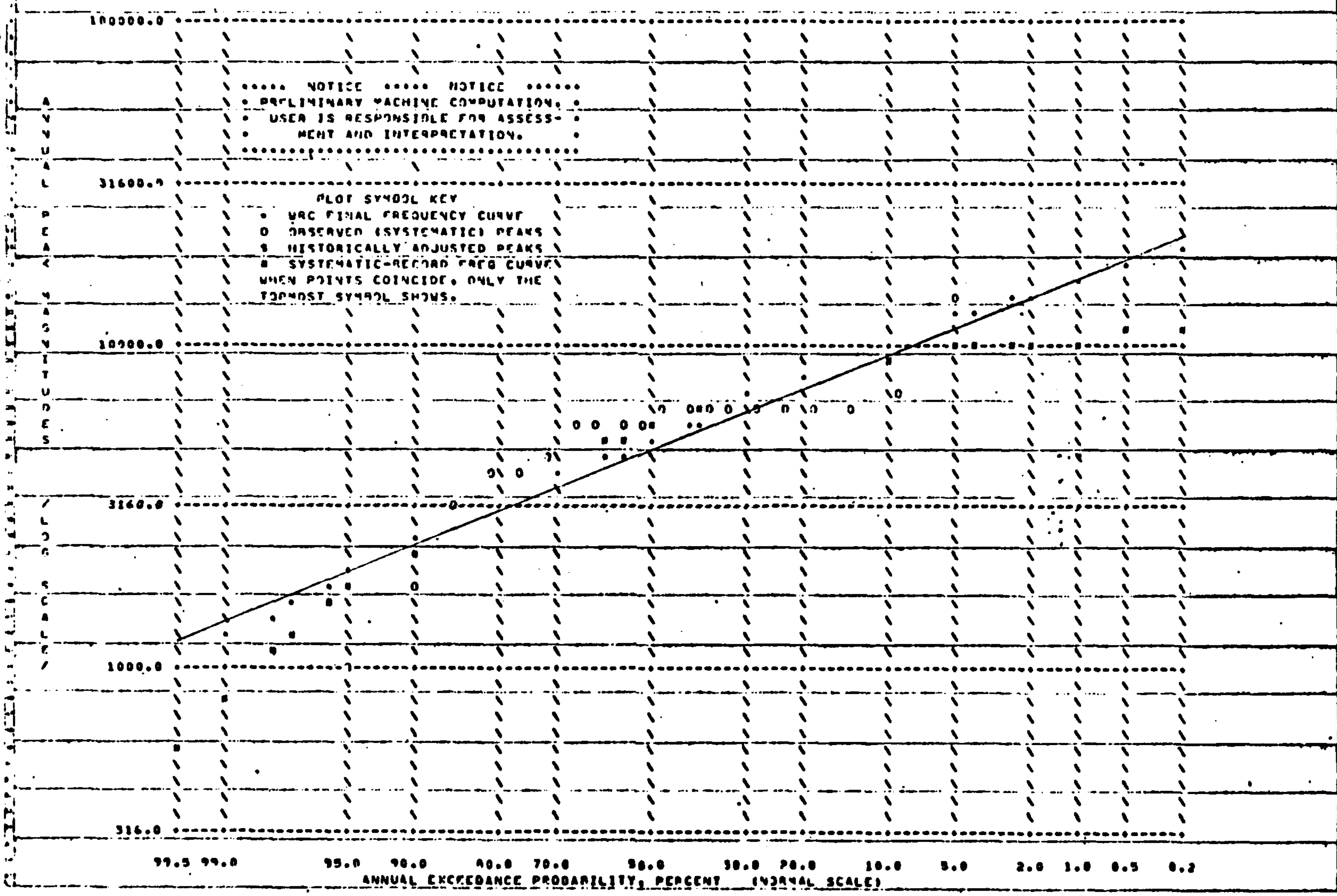
TORONTO

(PGM J407 VER 3.4
(REV 10/22/79)

U. S. GEOLOGIC[illegible] [illegible]VEY
ANNUAL PEAK FLOW FR[illegible] [illegible]CY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

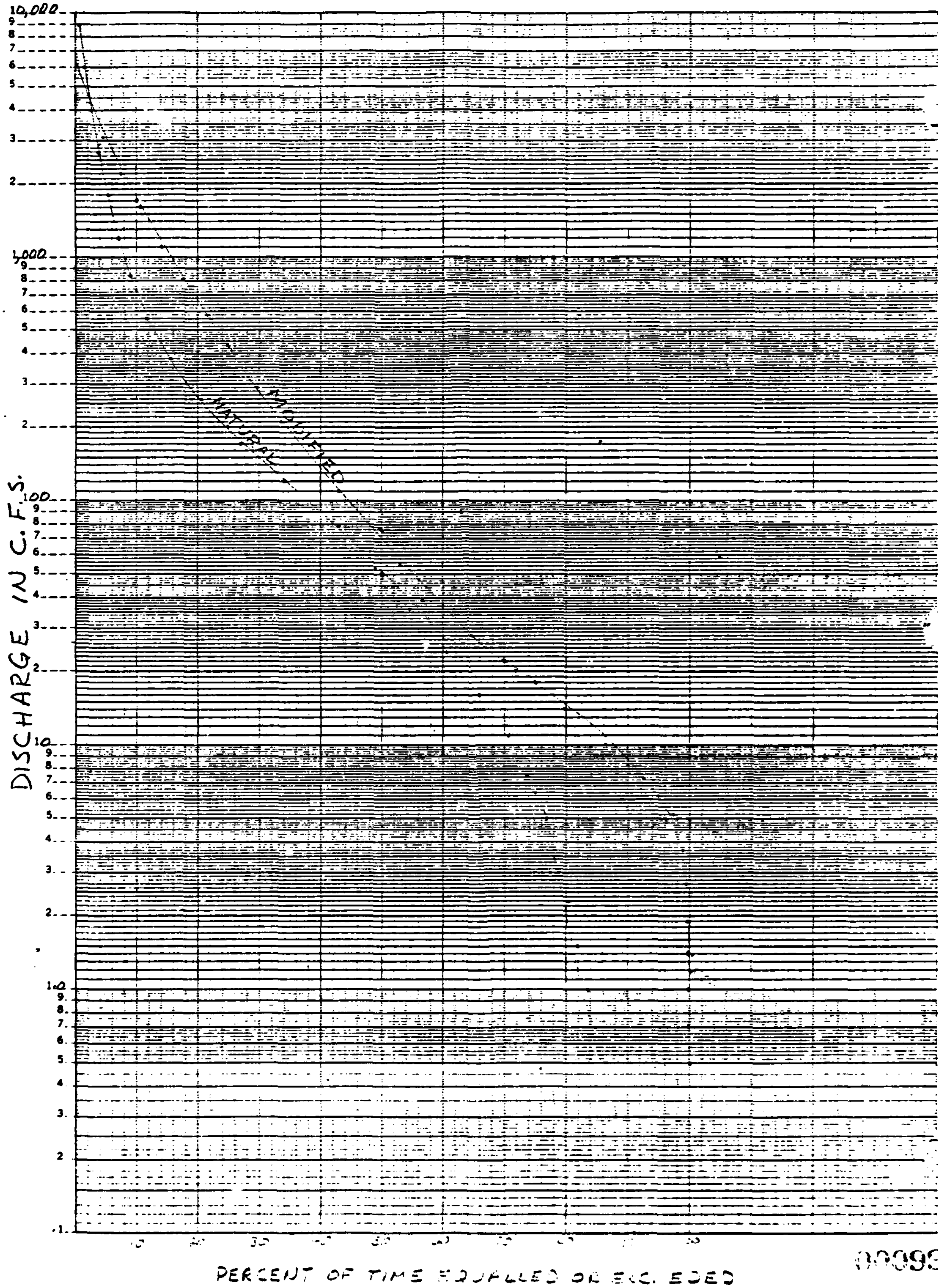
FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 3/80 AT 1605 SEQ 1.0001

STATION - 07166000/USGS VERDIGRIS R NR COYVILLE, KS 1960-1979 07166000/USGS



00098

TORONTO - VERDIGRIS 2.



K•E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 6213

00099

STORET RE[illegible]AL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 [illegible]07 VC-30 STV 2.SUMMARY.1
WQ DATA 3[illegible]S BELOW TORONTO

37 43 13.0 095 54 22.0 5
VERDIGRIS R BELOW TORONTO RES
20205 KANSAS
ARKANSAS 100320
VERDIGRIS BASIN
21KAN001 790818
0999 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 72/10/11 TO 76/04/27

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01046 IRON FE,SUSP UG/L
NO OF VALUES	14	0	0	0	0	0	0	14	0	0
MEAN	16.36	0.0	0.0	0.	0.0	0.0	0.	6.950	0.0	0.0
MEDIAN	16.50	0.0	0.0	0.	0.0	0.0	0.	7.200	0.0	0.0
NO OF VIOLS	0	0	0	0	0	0	0	2	0	0
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	14.	0.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	4.700	0.0	0.0
MEAN VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	4.750	0.0	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	4.800	0.0	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

00160

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 2.SUMMARY.2
WQ DATA 3 MILES BELOW TORONTO

002607 VE-30
37 43 13.0 095 54 22.0 5
VERDIGRIS R BELOW TORONTO RES
20205 KANSAS
ARKANSAS 100320
VERDIGRIS BASIN
21KAN001 790818
0999 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 72/10/11 TO 76/04/27

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	0	0	0	0	0	0	0	0	0	14
MEAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	49.00
MEDIAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	55.00
NO OF VIOLS	0	0	0	0	0	0	0	0	0.	8
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	0.	0.	57.
MINIMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	55.00
MEAN VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	60.00
MAXIMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	70.00
MIN CRITERIA	....	....	....	....	....	6.500	....	....	....	....
MAX CRITERIA	50.00	50.00	2.000	10.000	8.500	....	10.000	50.00	5000.	50.00

00101

1. Project Name: Fall River Lake

2. Project Location: River mile 54.3 of Fall River tributary to Verdigris River. Project watershed (585 square miles) located in Kansas; downstream management control stations located in Kansas.

3. Type of Project:

a. General category: Multiple-purpose storage reservoir (excluding hydropower).

b. Storage allocations:

	Elevation (feet) (N.G.V.D.)	Storage Acre-feet	Storage Inches Runoff
Top Flood Control Pool	987.5	256,400	8.22
Top Conservation Pool	948.5	21,900	.70
Bottom Conservation Pool	940.0	6,900	.22

c. Hydropower category: none

4. Water Management Criteria:

a. Authorized project purposes: flood control and conservation

b. Water use contracts: none

c. Interagency agreements: Agreement with Kansas State Fish and Wildfish Department for pool level manipulation.

d. Informal commitments: none

e. System regulation objectives: Regulated as a system with Toronto and Elk City to retain equivalent flood control capabilities insofar as possible and total combined releases and local inflow not to exceed 20,000 cfs at Independence, KS and 30,000 cfs at Lenapah, OK.

5. Project Evaluation:

a. Effects of impoundments on water stored:

(1) Positive effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(2) Negative effects:

(a) Quality: Due to the basin morphometry, Fall River Lake stratifies only occasionally. Such weak and ephemeral stratification is not associated with water quality degradation.

(b) Quantity: The lake is operated under a water level management plan aimed at enhancing the fishery. This can cause tailwater fluctuations to be greater than normal.

6. Project Effect on Instream Flows:

(1) General: Discharge frequency and duration curves for natural and modified conditions are attached.

(2) Positive effects: Reductions in peak flows and increases in the low flows have been experienced since impoundment. Low flow augmentation on the Verdigris River is an additional benefit.

(3) Negative effects: Historical data from Fall River tailwater stations were compared to Kansas Class A water quality standards (see attachments). No significant violations of these standards were found, however, no data were available for many parameters.

(4) Project effects on system regulation: The project has a significant impact on the flood control capabilities of the Fall Creek and Verdigris River system.

7. Alternatives:

a. Reservoir regulation: none

b. Structural modification: none

c. Storage reallocation: none

d. Other: no action

8. Action Taken to Date: none

9. Planned Action: none

FALL RIVER
FALL RIVER, KANSAS

Top of Conservation (Power) Pool Elevation	948.5
Top of Flood Control Pool Elevation	987.5

OUTLET WORKS

Type	Sluice
Size	7-5'x8.5'
Intake Elevation	915.0
Control Gates	7-5'x8.5'
Capacity at Conservation Pool (c.f.s.)	11,400
Capacity at Flood Control Pool (c.f.s.)	17,780

WATER SUPPLY FACILITY

Low Flow	
Type	Pipe
Size	30" Dia.
Elevation	929.0
Capacity at Conservation Pool (c.f.s.)	68
Capacity at Flood Control Pool (c.f.s.)	101
Static Head Pipe	
Diameter	12" Dia.

SPILLWAY

Type	Ogee
Crest Width	400'
Crest Elevation	962.5
Control	8-50'x25' (Tainter Gates)
Capacity at Conservation Pool (c.f.s.)	0
Capacity at Flood Control Pool (c.f.s.)	200,000

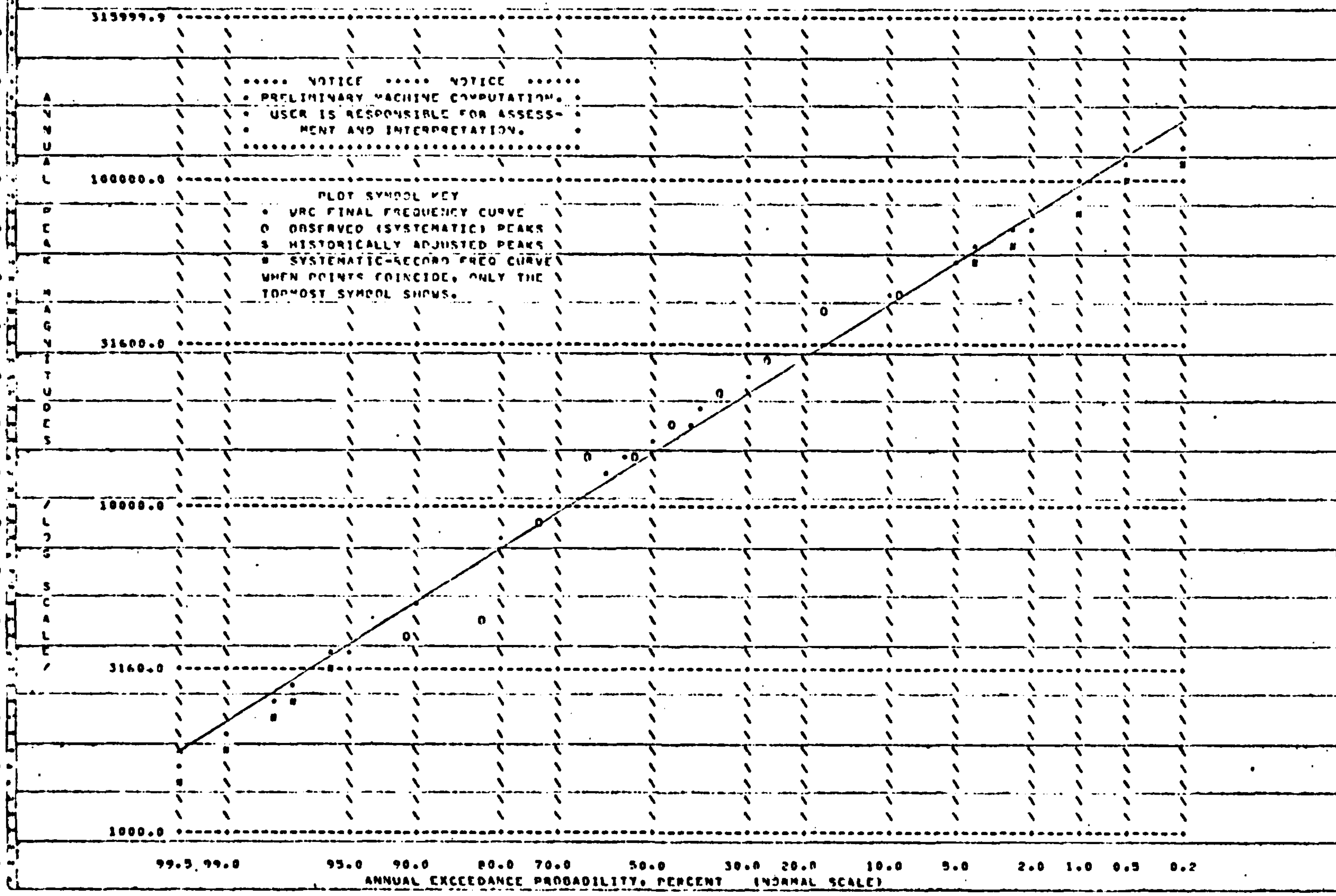
FALL RIVER-NATURAL

PGM J407 VER 3.4
(REV 10/22/79)

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 4/80 AT 1117 SEQ 1.0001

STATION - 07168500/USGS FALL R NR FALL RIVER, KS 1923-1979 07168500/USGS

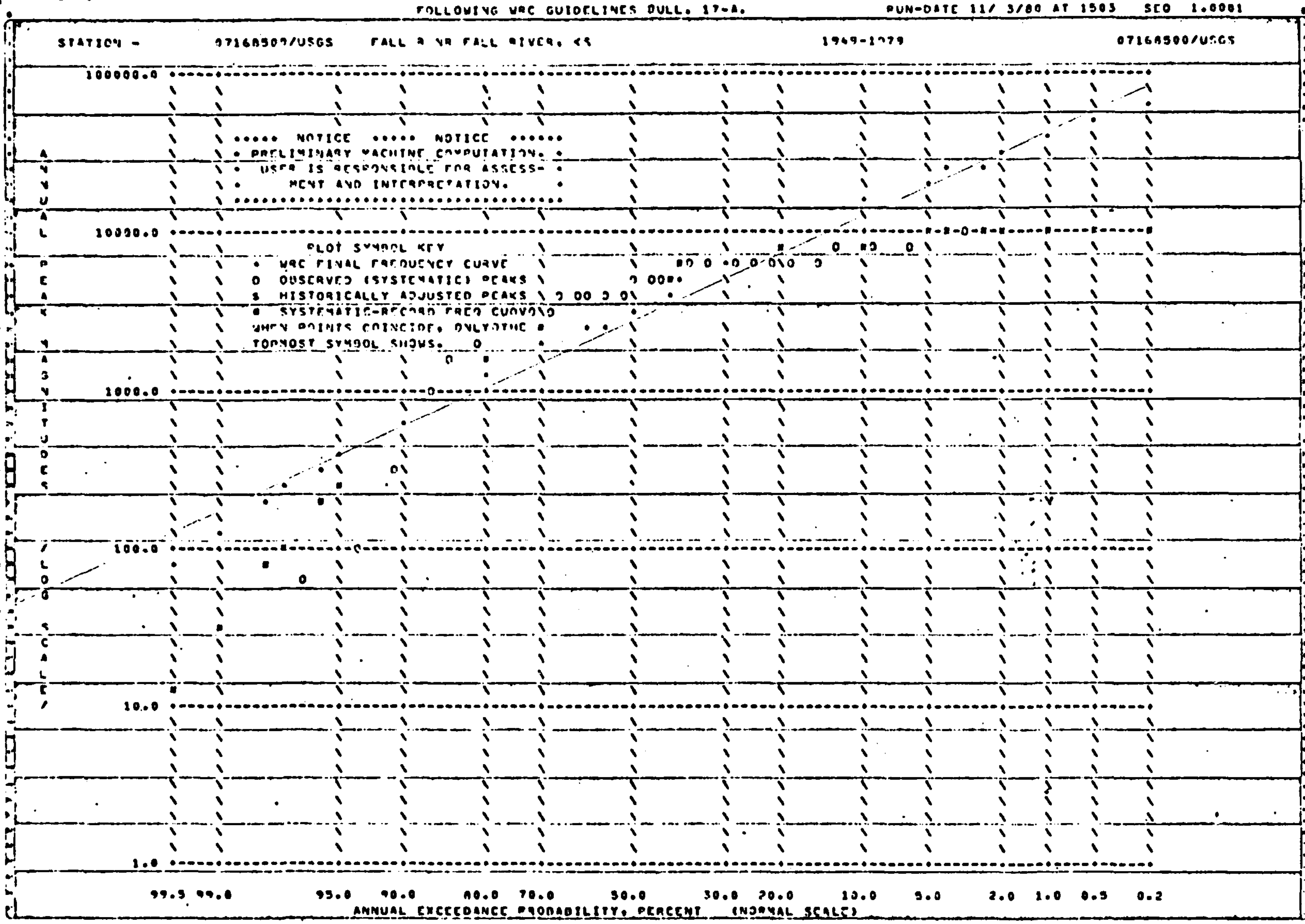


FALL RIVER - MODIFIED

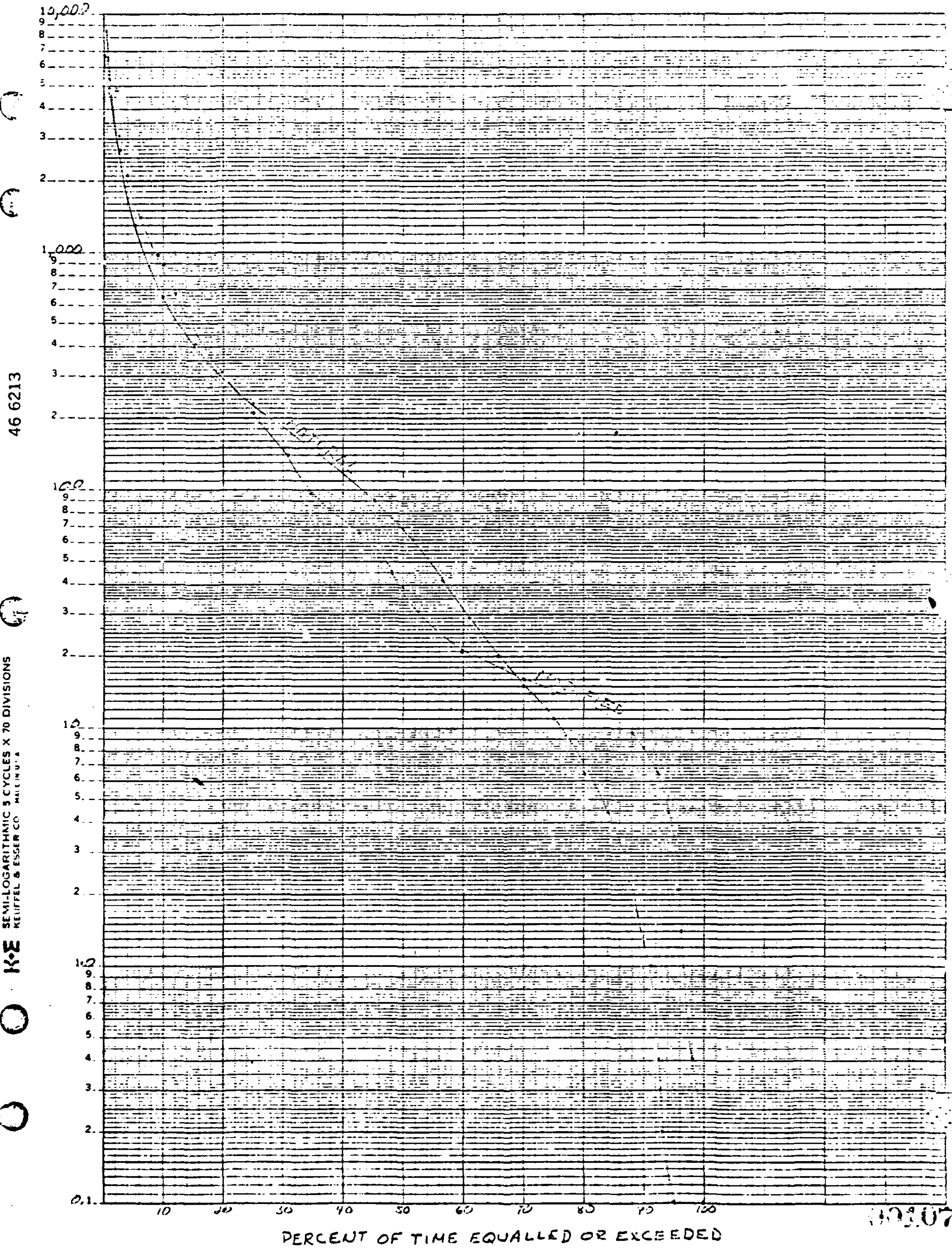
J407 VER 3.4 (REV 10/22/79)

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 3/80 AT 1503 SEQ 1.0001



FALL RIVER LAKE - FALL RIVER



STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 1.SUMMARY.1

42 DATA 1 MILE BELOW FALL RIVER

002605 FA-28
37 24 04.0 095 41 28.0 5
FALL RIVER NEAR FALL RIVER RES
20205 KANSAS
ARKANSAS 100320
VERDIGRIS BASIN
21KAN001 790818
0999 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 72/10/11 TO 76/04/27

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	14	6	0	0	0	0	0	14	0	0
MEAN	15.79	0.222	0.0	0.	0.0	0.0	0.	6.150	0.0	0.0
MEDIAN	15.50	0.230	0.0	0.	0.0	0.0	0.	6.100	0.0	0.0
NO OF VIOLS	0	0	0	0	0	0	0	0	0	0
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MEAN VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

00108

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980

NO DATA 1 MILE BELOW FALL RIVER

STN 1.SUMMARY.2

002605 FA-28
37 24 04.0 095 41 29.0 5
FALL RIVER NEAR FALL RIVER RES
20205 KANSAS
ARKANSAS 100320
VERDIGRIS BASIN
21KAN001 790819
0999 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 72/10/11 TO 76/04/27

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	0	0	0	0	0	0	0	0	0	14
MEAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	23.71
MEDIAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	18.00
NO OF VIOLS	0	0	0	0	0	0	0	0	0	2
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	0.	0.	14.
MINIMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	55.00
MEAN VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	62.50
MAXIMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	70.00
MIN CRITERIA	*********	*********	*********	*********	6.500	*********	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	*********	8.500	10.000	50.00	5000.	50.00

1. Project Name: Elk City Lake

2. Project Location: River mile 8.7 on Elk River tributary to Verdigris River. Project watershed (634 square miles) located in Kansas; downstream management control stations located in Kansas.

3. Type of Project:

a. General Category: multiple-purpose storage reservoir (excluding hydropower).

b. Storage Allocations:

	Elevation (Feet N.G.V.D.)	Storage Ac. Ft.	Storage Inches of Runoff
Top Flood Control Pool	825.0	284,300	8.41
Top Conservation Pool	796.0	44,800	1.32
Bottom Conservation Pool	764.0	350	.01
Water Supply Storage (10 mgd)		24,300	
Water Quality Storage (7.4 mgd)		18,000	

4. Water Management Criteria:

a. *Authorized Project Purpose: flood control, water supply, and* water quality.

b. Water Use Contracts: Water storage 10 mgd.

c. Interagency Agreements: The state of Kansas contracts for all the water supply storage available.

d. Informal Commitments: None.

e. System Regulation Objectives: Regulated as a system with Toronto and Fall River to retain equivalent flood control capabilities insofar as possible and total combined releases and local inflow to exceed 20,000 cfs at Independence, Kansas and 30,000 cfs at Lenapah, Oklahoma.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive Effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(b) Quantity: The lake provides storage for flow augmentation in times of drought.

(2) Negative Effects:

Quality: Due to the basin morphometry, Elk City Lake stratifies only occasionally. Such weak and ephemeral stratification is not associated with water quality degradation.

b. Project Effect on Instream Flows:

(1) General: Discharge frequency and duration curves are attached for natural and modified conditions.

(2) Positive Effects: Reductions in peak flows have been observed since impoundment. Although low flows have been decreased immediately downstream, low flow augmentation of the Verdigris River is improved.

(3) Negative Effects: The lake is operated under a water level management plan designed to enhance the fishery. This can cause tailwater fluctuations to be greater than normal. Historical data from Elk City tailwater stations were compared to Kansas Class A water quality standards (see attachments). No significant violations of these standards were found, however, no data were available for many parameters.

c. Project Effects on System Regulation: The project adds a significant flood control capability to the Verdigris River and supports the low flow requirements of the Verdigris River.

7. Alternatives:

a. Reservoir Regulation: None.

b. Structural Modification: None.

c. Storage Reallocation: None.

d. Other: No action.

8. Action Taken to Date: None.

9. Planned Action: None.

ELK CITY
ELK RIVER, KANSAS

Top of Conservation (Power) Pool Elevation	796.0
Top of Flood Control Pool Elevation	825.0

OUTLET WORKS

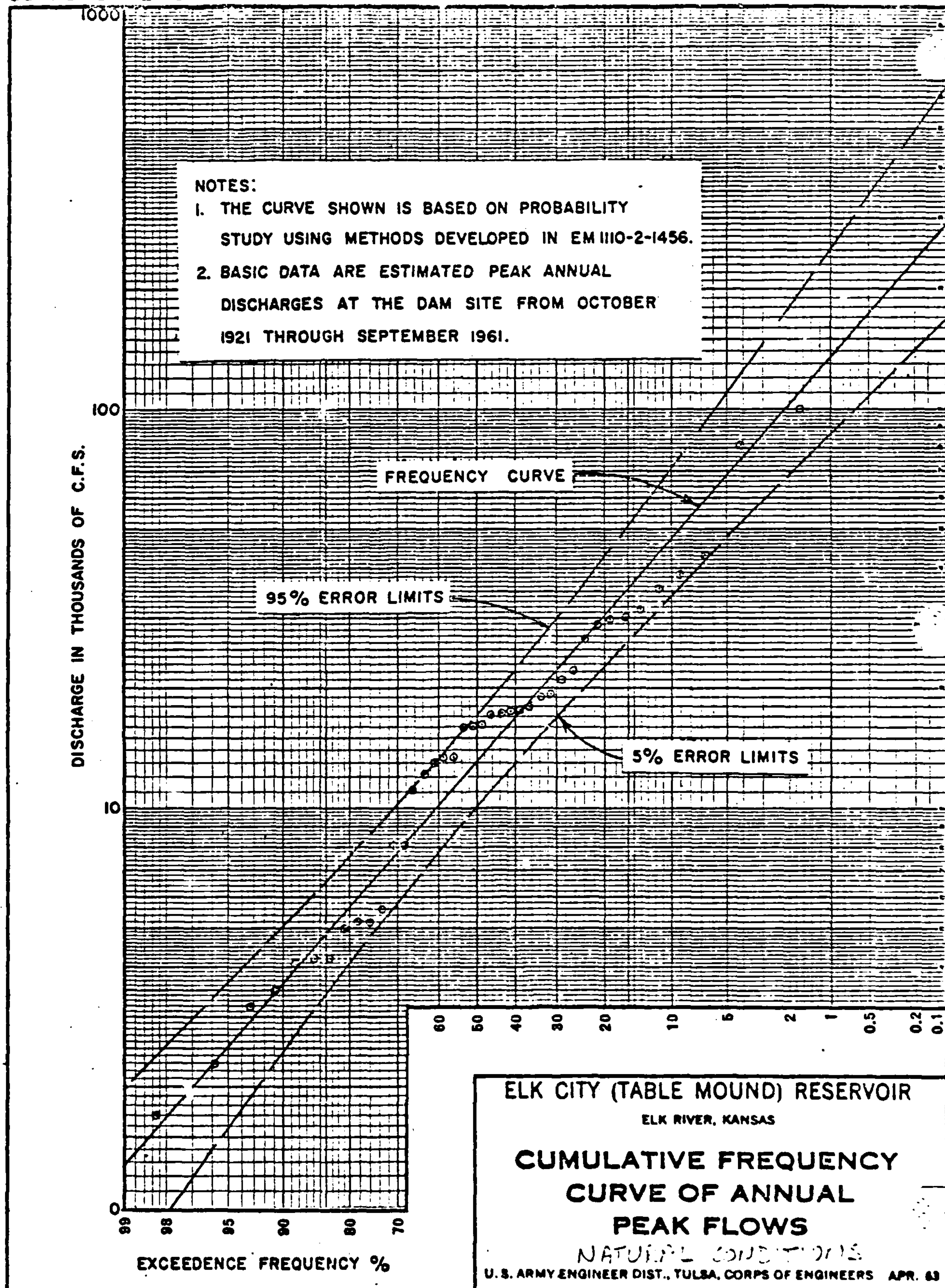
Type	Conduit
Size	16.0' Dia.
Intake Elevation	742.0
Control Gates	2-7'x16'
Capacity at Conservation Pool (c.f.s.)	9020
Capacity at Flood Control Pool (c.f.s.)	11,500

WATER SUPPLY FACILITY

Low Flow	
Type	Pipe
Size	24" Dia.
Elevation	759.25
Capacity at Conservation Pool (c.f.s.)	89
Capacity at Flood Control Pool (c.f.s.)	120
Static Head Pipe	
Diameter	24" Dia.
Elevation	778.0 and 760.0

SPILLWAY

Type	Ogee
Crest Width	400'
Crest Elevation	825.31
Control	Uncontrolled
Capacity at Conservation Pool (c.f.s.)	0
Capacity at Flood Control Pool (c.f.s.)	0



ELK CITY (TABLE MOUND) RESERVOIR

ELK RIVER, KANSAS

CUMULATIVE FREQUENCY CURVE OF ANNUAL PEAK FLOWS

NATURAL CONDITIONS

U. S. ARMY ENGINEER DIST., TULSA, CORPS OF ENGINEERS APR. 63

DRAWN: E. D.

CHECKED E. B. S.

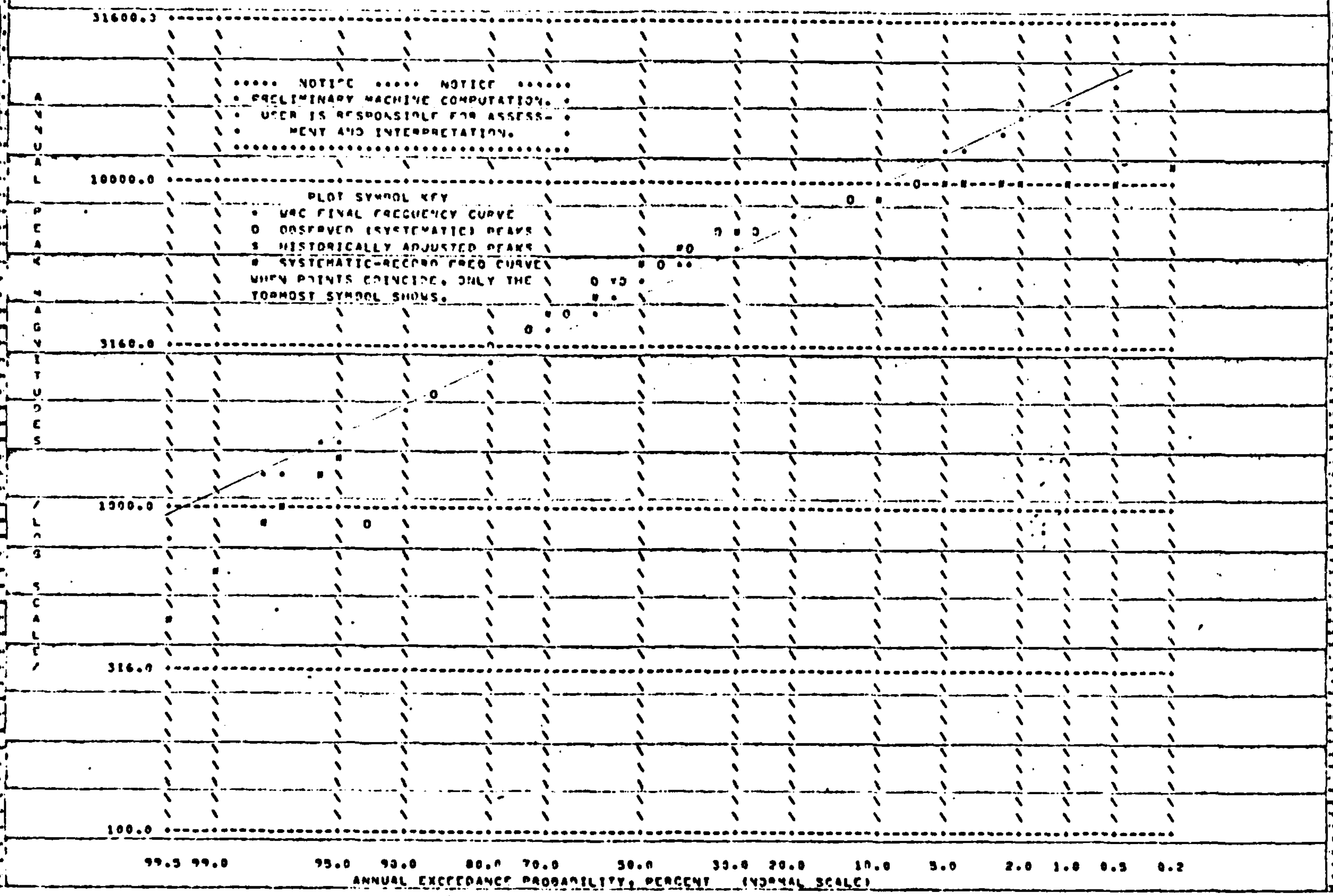
MODIFIED ELK

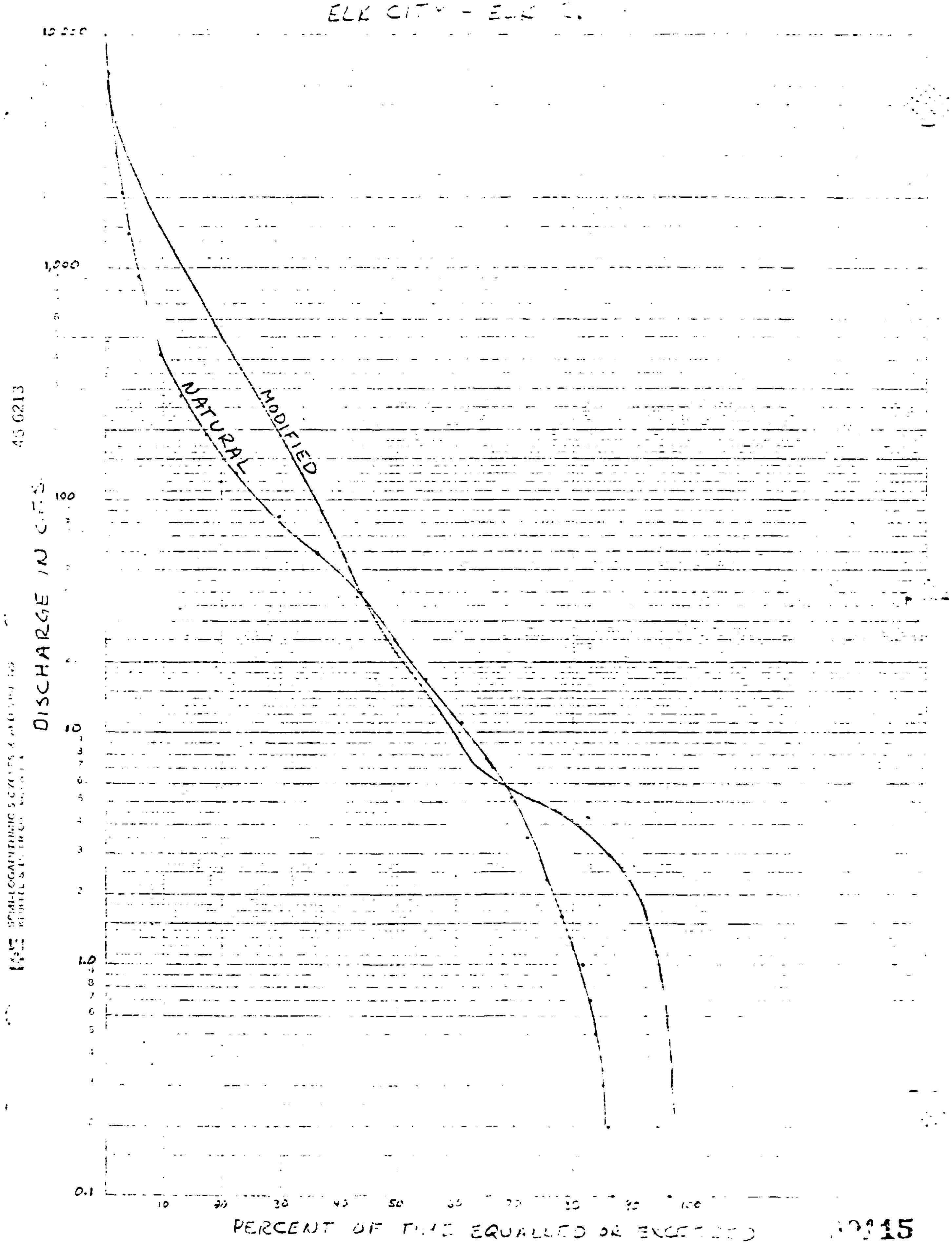
J407 VER 3.4
EV 10/22/79)

U. S. GEOLOGICAL Y
ANNUAL PEAK FLOW FREQ ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 3/80 AT 1457 SEQ 1.0001

STATION - 07170060/USGS ELK R NL ELK CITY LK, KS 1966-1979 07170060/USGS




ELK CITY - ELK C.
MODIFIED
NATURAL
DISCHARGE IN C.F.S.
PERCENT OF TIME EQUALLED OR EXCEEDED
10,000
1,000
100
10
1.0
0.1
10
20
30
40
50
46 6213

STORET RETR DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 1.SUMMARY.2
JC DATA 2 TO MILES BELOW ELK CITY

00..6
37 16 46.0 095 46 53.0 3
ELK R. BL ELK CITY DAM, KS.
20125 KANSAS
ARKANSAS R. BASIN. 100391
VERDIGRIS UNIT.
21KAN001
0000 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 74/01/22 TO 80/03/04

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	0	0	9	0	0	0	0	0	0	16
MEAN	0.0	0.0	0.111	0.0	0.0	0.0	0.0	0.0	0.	90.94
MEDIAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	65.00
NO OF VIOLS	0	0	0	0	0	0	0	0	0	12
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	0.	0.	75.
MINIMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	55.00
MEAN VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	110.42
MAXIMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	200.00
MIN CRITERIA	*********	*********	*********	*********	*********	6.500	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	8.500	*********	10.000	50.00	5000.	50.00

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 2.SUMMARY.1

WQ DATA 2 TO 4 MILES BELOW ELK CITY

002602 EL-25
37 17 05.0 095 45 56.0 5
ELK RIVER BELOW ELK CITY RES
20125 KANSAS
ARKANSAS 100330
VERDIGRIS BASIN
21KAN001 790819
0999 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 72/10/11 TO 76/04/27

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	12	0	0	0	0	0	0	14	0	0
MEAN	16.33	0.0	0.0	0.	0.0	0.0	0.	7.271	0.0	0.0
MEDIAN	16.00	0.0	0.0	0.	0.0	0.0	0.	7.250	0.0	0.0
NO OF VIOLS	0	0	0	0	0	0	0	0	0	0
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MEAN VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MIN CRITERIA	....	....	....	....	....	....	....	5.000	....	....
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	....	1.400	300.0

STORET RET L DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 2.SUMMARY.2
WQ DATA 2 MILES BELOW ELK CITY

0. 02 EL-25
37 17 05.0 095 45 56.0 5
ELK RIVER BELOW ELK CITY RES
20125 KANSAS
ARKANSAS 100330
VERDIGRIS BASIN
21KAN001 790819
0999 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 72/10/11 TO 76/04/27

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	0	0	0	0	0	0	0	0	0	14
MEAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	35.21
MEDIAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	15.00
NO OF VIOLS	0	0	0	0	0	0	0	0	0	5
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	0.	0.	36.
MINIMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	55.00
MEAN VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	66.00
MAXIMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	70.00
MIN CRITERIA	*********	*********	*********	*********	*********	6.500	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	8.500	*********	10.000	50.00	5000.	50.00

03318

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 1.SUMMARY.1
42 DATA 2 TO 4 MILES BELOW ELK CITY

000276
37 16 46.0 095 46 53.0 3
ELK R. BL ELK CITY DAM, KS.
20125 KANSAS
ARKANSAS R. BASIN. 100391
VERDIGRIS UNIT.
/TYPA/AMBNT/STREAM 21KAN001
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 74/01/22 TO 80/03/04

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	66	65	0	0	0	0	0	66	0	0
MEAN	15.14	0.211	0.0	0.	0.0	0.0	0.	8.832	0.0	0.0
MEDIAN	15.50	0.200	0.0	0.	0.0	0.0	0.	8.050	0.0	0.0
NO OF VIOLS	0	0	0	0	0	0	0	4	0	0
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	6.	0.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	3.800	0.0	0.0
MEAN VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	4.375	0.0	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	4.800	0.0	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

1. Project Name: Big Hill

2. Project Location: River Mile 33.3 on Big Hill Creek Tributary to Verdigris River. Project watershed (36.9 square miles) located in Kansas; downstream management control stations located in Kansas.

3. Type of Project:

a. General category: Multi-purpose storage reservoir (excluding hydropower).

b. Storage allocations:

	Elevation Feet (N.G.V.D.)	Storage Acre-Feet	Storage Inches Runoff
Top Flood Control Pool	867.5	40,600	20.6
Top Conservation Pool	858.0	27,500	14.0
Bottom Conservation Pool	814.0	290	.2
Water Supply Storage (8.5 mgd)		25,700	

c. Hydropower category: None

4. Water Management Criteria:

a. Authorized project purposes: Flood control, water supply, and recreation.

b. Water use contracts: Water storage 8.5 mgd.

c. Interagency agreements: None

d. Informal commitments: None

e. System regulation objectives: Regulated in the Verdigris River System to control floods and retain equivalent flood control capabilities with other projects in the system as much as possible.

5. Project Evaluation:

a. Effects of impoundment on water stored:

(1) Positive effects:

Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(2) Negative effects:

Quality: Due to basin morphometry, the lake only stratifies occasionally and is not expected to cause significant water quality degradation.

b. Project effect on instream flows:

(1) General: The discharge frequency curve for natural conditions and the duration curves for natural and modified conditions are attached. As of November 1980, the project is not operational.

(2) Positive effects: Reduction of peak flows is expected. The low flows in the stream are expected to be enhanced.

(3) Negative effects: None expected.

c. Project effects on system regulation: The project has minimal effects on the flood control capability of the Verdigris River System.

6. Constraints and Obtaining Instream Quantity and Quality Objectives: The flood releases are uncontrolled.

7. Alternatives:

a. Reservoir regulation: None

b. Structural modification: None

c. Storage reallocation: None

d. Other: No action

8. Action Taken to Date: None

9. Planned Action: None

BIG HILL
BIG HILL CREEK, KANSAS

Top of Conservation (Power) Pool Elevation	858.0
Top of Flood Control Pool Elevation	867.5

OUTLET WORKS

Type	Conduit (Two-Way Riser)
Size	5'-8" Diameter
Intake Elevation	858.0
Control Gates	None
Capacity at Conservation Pool (c.f.s.)	0
Capacity at Flood Control Pool (c.f.s.)	1000

WATER SUPPLY FACILITY

Intakes

Number	1	1	1	2
Size	1.5'x2.0'	1.5'x2.0'	1.5'x2.0'	3.0'x5.0'
Elevation	851.0	844.0	829.0	813.0

Low Flow

Type	Gate
Size	2-2.0'x5.0'
Elevation	813.0
Capacity at Conservation Pool (c.f.s.)	790
Capacity at Flood Control Pool (c.f.s.)	1010

Static Head Pipe

Diameter	30" Diameter
Elevation	806.5

SPILLWAY

Type	Excavated
Crest Width	400'
Crest Elevation	869.5
Control	Uncontrolled
Capacity at Conservation Pool (c.f.s.)	0
Capacity at Flood Control Pool (c.f.s.)	0

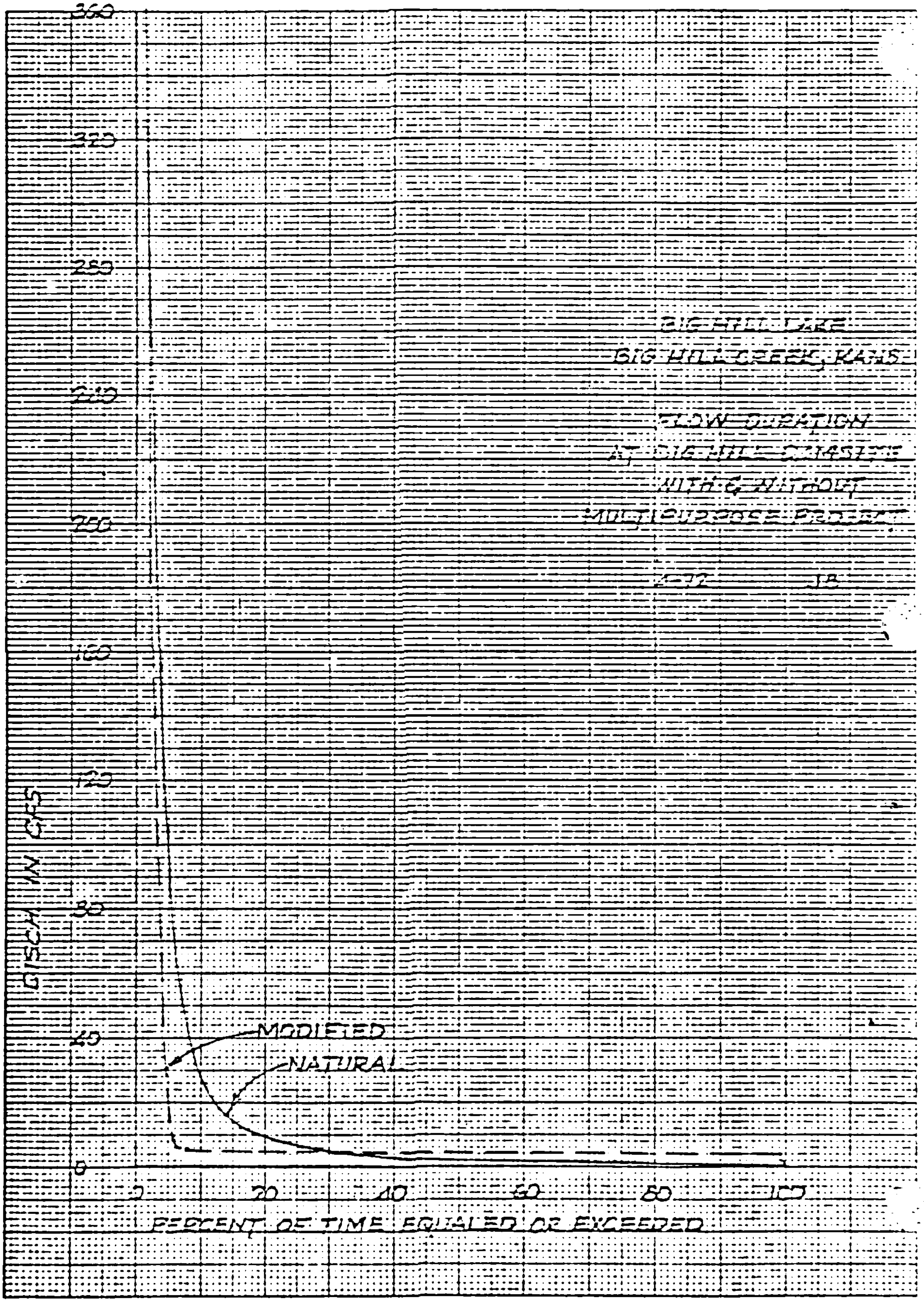
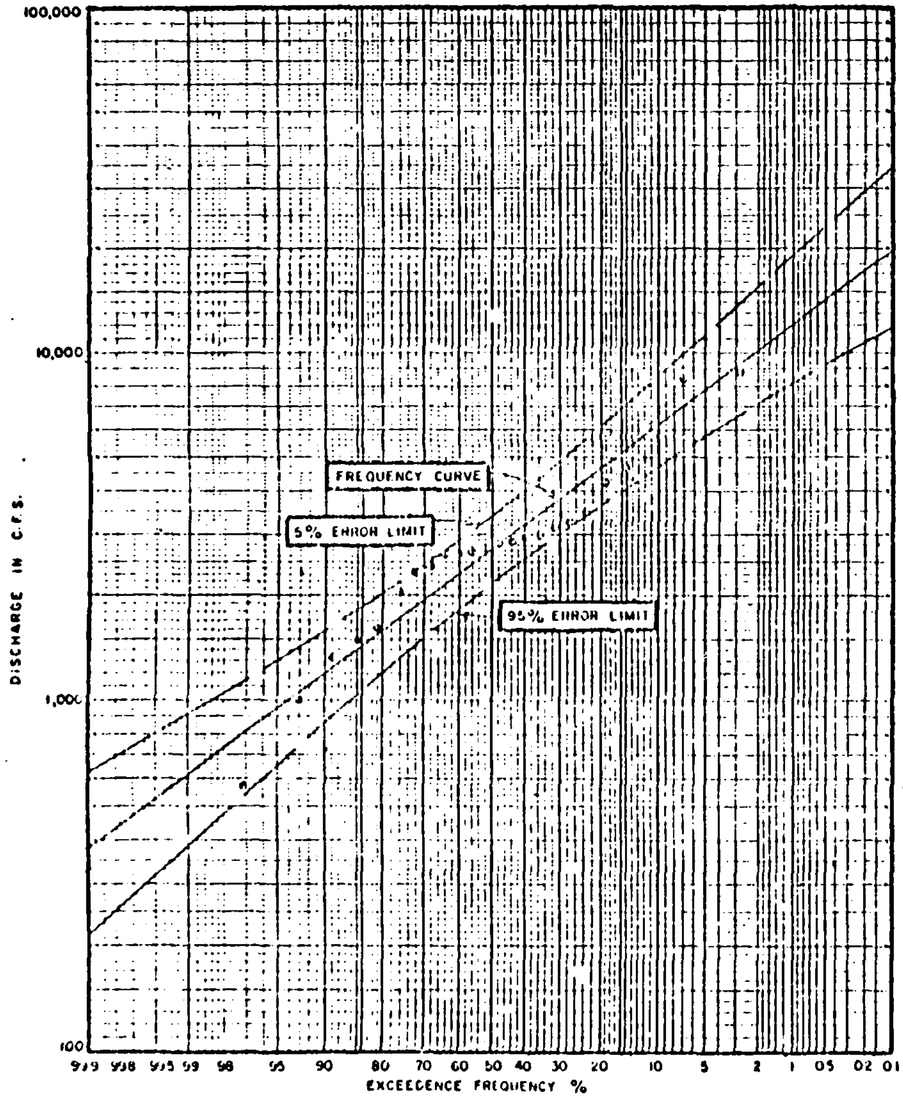

BIG HILL CREEK, KANS
FLOW DURATION
WITH & WITHOUT
MODIFIED
NATURAL
DISCH IN CFS
0
20
40
60
80
100
PERCENT OF TIME EQUALED OR EXCEEDED

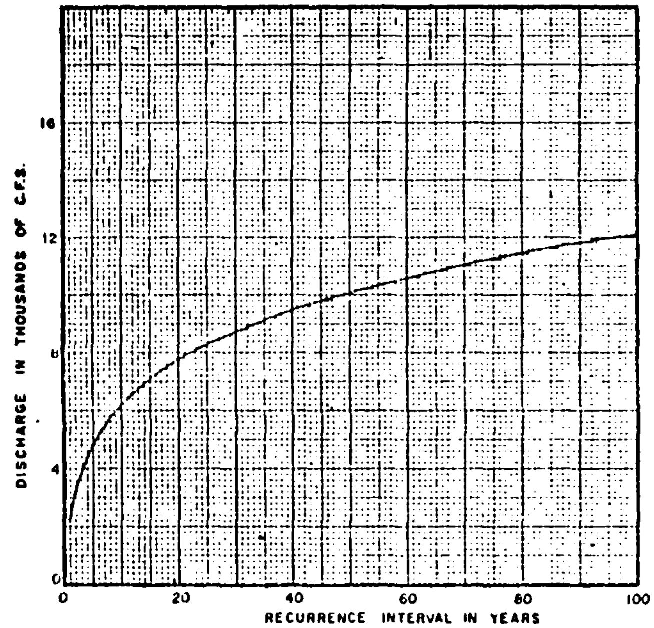
PLATE 2

CORPS OF ENGINEERS

U. S. ARMY



CUMULATIVE FREQUENCY CURVE OF ANNUAL PEAK FLOWS



DISCHARGE PROBABILITY UNDER NATURAL CONDITIONS

NOTES:

1. BASED ON METHODS OUTLINED IN "STATISTICAL METHODS IN HYDROLOGY" LEO R. BEARD, JAN 1962.
2. BASIC DATA ARE ESTIMATED ANNUAL PEAK DISCHARGES AT THE DAM SITE FROM JAN 1940 THROUGH DEC 1963

BIG HILL RESERVOIR
BIG HILL CREEK, KANSAS

PEAK DISCHARGE FREQUENCY CURVES

U. S. ARMY ENGINEER DIST., TULSA, CORPS OF ENGINEERS MAY 64
DRAWN: J.L.H
CHECKED: J.E.L

1. Project Name: Oologah Lake

2. Project Location: River mile 90.2 on Verdigris River tributary to Arkansas River. Project watershed (4,339 square miles) located in Oklahoma; downstream management control stations located in Oklahoma and Arkansas.

3. Type of Project:

a. General Category: Multiple-purpose storage reservoir (excluding hydropower).

b. Storage Allocations:

	Elevation (feet) (N.G.V.D.)	Storage Acre Feet	Storage Inches Runoff
Top Flood Control Pool	661.0	1,519,000	6.56
Top Conservation Pool	638.0	553,400	2.39
Bottom Conservation Pool	592.0	9,300	.04
Water Supply Storage (154 mgd)		342,600	

4. Water Management Criteria:

a. Authorized project purposes: flood control, water supply, and navigation.

b. Water use contracts: existing water storage-6.5 mgd, pending water storage-129.0 mgd and water withdrawal-4.5 mgd.

c. Interagency agreements: none

d. Informal commitment: none

e. System regulation objectives: The project is regulated in the system to control floods while retaining equivalent flood control capabilities with other projects in the system.

5. Project Evaluation:

a. Effects of impoundment on water stored:

(1) Positive effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

b. Quantity: The lake provides storage for flow augmentation in times of drought.

(2) Negative effects:

(a) Quality: Oologah Lake becomes thermally stratified from early summer through mid-fall. Chemical reactions within the anoxic hypolimnion cause an increase in dissolved iron and manganese within this zone. The water in the hypolimnion decreases in pH and temperature while ammonia and hydrogen sulfide levels are elevated. When the lake returns to complete mixing in the fall, water quality becomes more desirable.

(b) Quantity: Flood releases cause tailwater fluctuations to be more rapid than normal.

(3) Cause of negative effects: Soils within the watershed are high in iron and manganese. Agricultural operations lead to large input of these soils of the lake.

b. <u>Project effects on instream flows</u>:

(1) General: Discharge frequency and duration curves for natural and modified conditions are attached. The project is being studied for possible conversion to hydropower.

(2) Positive effects: Peak flow magnitudes have been reduced and low flow durations have been slightly increased.

(3) Negative effects: Historical data from Oologah tailwater stations were compared to Oklahoma Raw Water Supply Standards (see attachments). These drinking water standards were used because Oklahoma has few numerical standards for other water classes. No significant violations of these standards were noted, however, low dissolved oxygen levels have been measured in the basin.

(4) Cause of negative effect: Water withdrawn from the hypolimnion for release is anoxic. Apparently, turbulence from the release is sufficient to allow this water to meet State standards at a point 0.3 mile below the outlet.

c. <u>Project effects on system regulation</u>: The project has a significant flood control effect on the Verdigris River and navigation channel.

6. <u>Constraints on Obtaining Instream Quantity and Quality Objectives</u>: Unable to make selective water level withdrawals for downstream releases. The flood control releases are determined by and limited to the requirements specified by the navigation taper needs.

7. <u>Alternatives</u>:

a. <u>Reservoir regulation</u>: none

b. <u>Structural modification</u>: none

c. <u>Storage reallocation</u>: none

d. <u>Other</u>: no action

8. <u>Action Taken to Date</u>: none

9. <u>Planned Action</u>: none

OOLOGAH
VERDIGRIS RIVER, OKLAHOMA

Top of Conservation (Power) Pool Elevation	638
Top of Flood Control Pool Elevation	661

OUTLET WORKS

Type	Conduit
Size	2-19' Dia.
Intake Elevation	565
Control Gates	4-9'x19'
Capacity at Conservation Pool (c.f.s.)	30,000
Capacity at Flood Control Pool (c.f.s.)	35,000

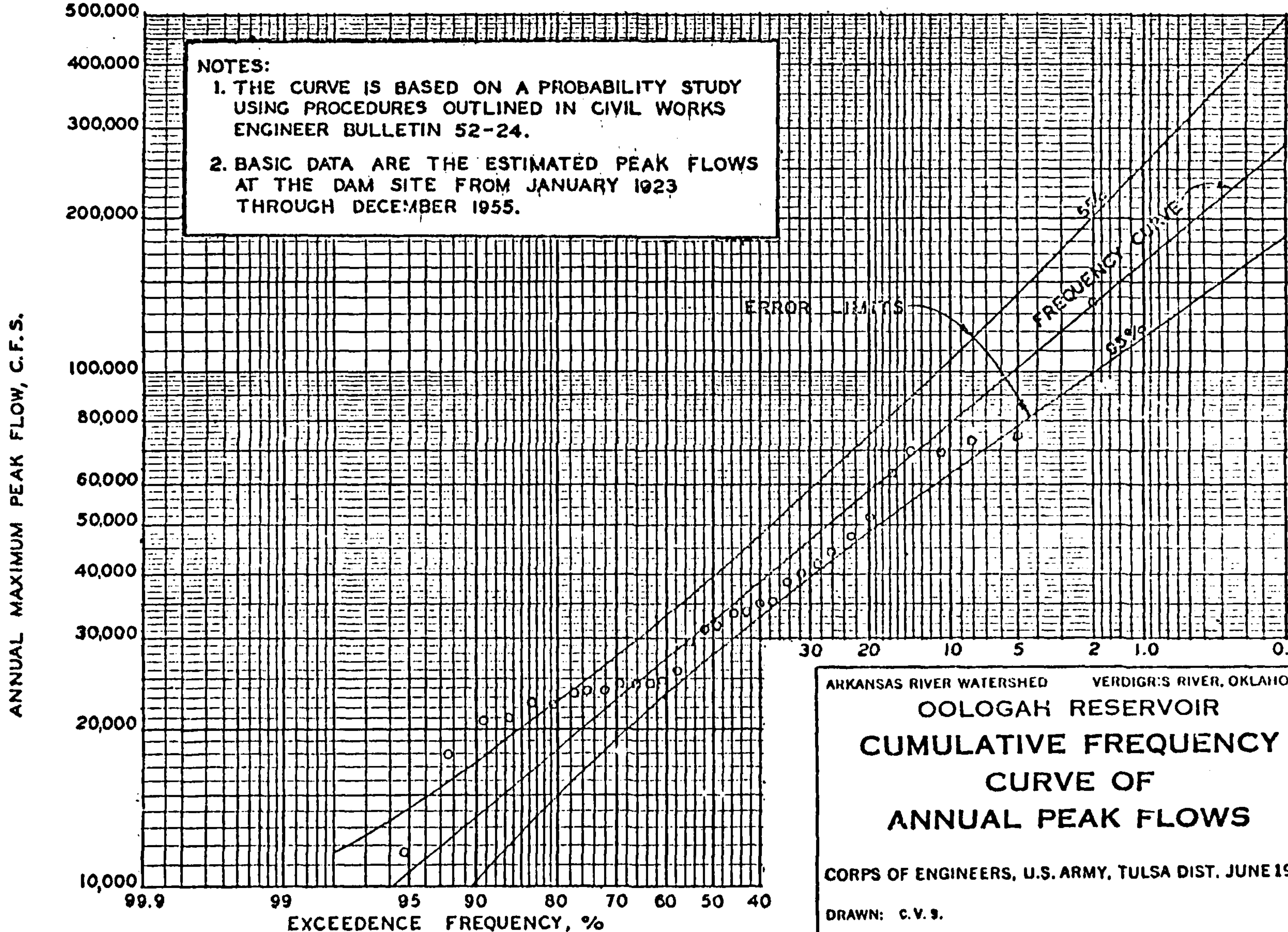
WATER SUPPLY FACILITY

Low Flow		
Type		Pipe
Size		48" Dia.
Elevation		574.5
Capacity at Conservation Pool (c.f.s.)		550
Static Head Pipe		
Diameter	84" Dia. Inlet	64" Dia. Outlet
Elevation		565

SPILLWAY

Type	Ogee
Crest Width	280
Crest Elevation	640
Control	7-40'x21' (Tainter Gates)
Capacity at Conservation Pool (c.f.s.)	0
Capacity at Flood Control Pool (c.f.s.)	36,000

NATURAL



ARKANSAS RIVER WATERSHED VERDIGRIS RIVER, OKLAHOMA

OOLOGAH RESERVOIR

CUMULATIVE FREQUENCY CURVE OF ANNUAL PEAK FLOWS

CORPS OF ENGINEERS, U.S. ARMY, TULSA DIST. JUNE 1956

DRAWN: C.V.S.

CHECKED: R.B.C.

PLATE 12

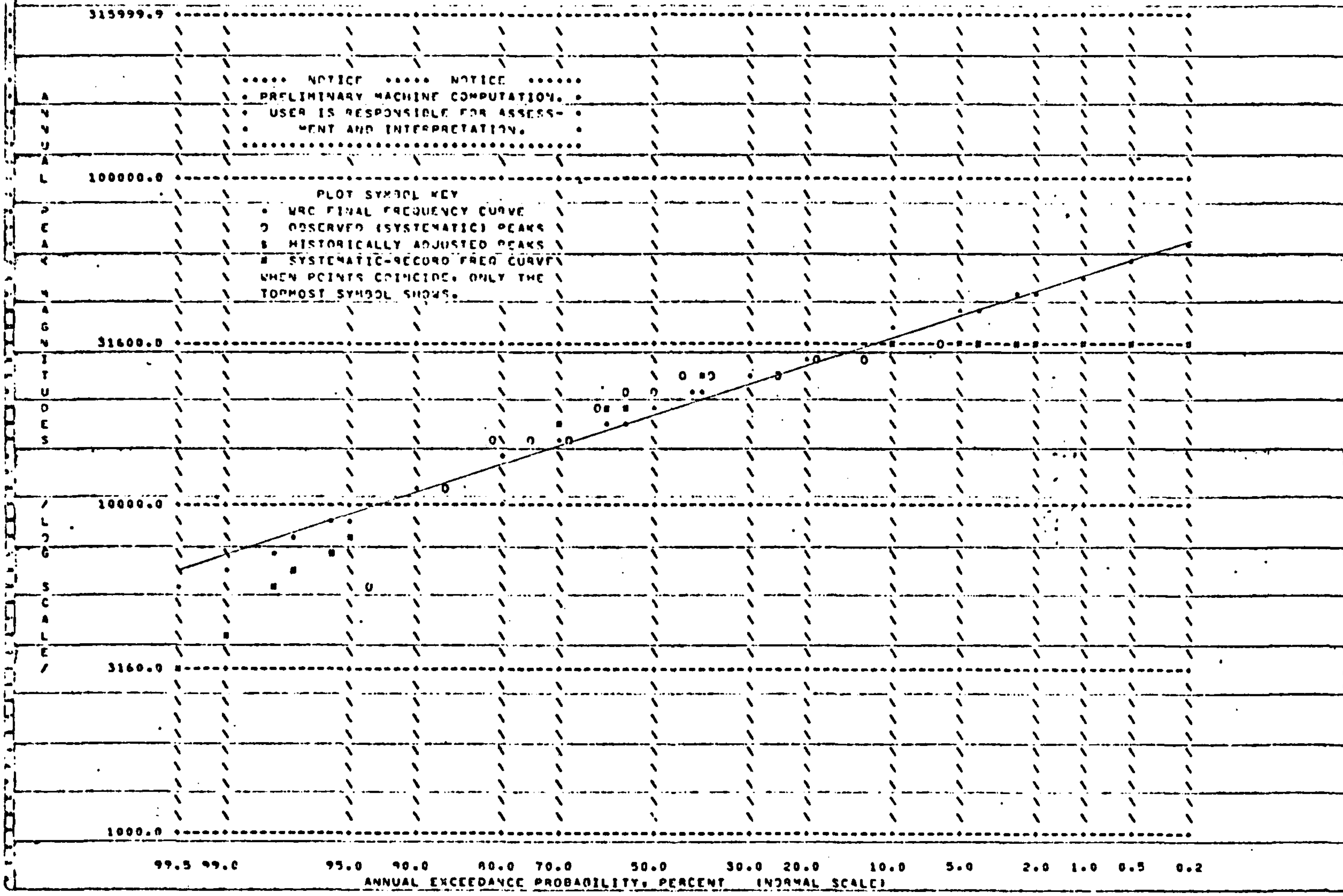
OOLOGAH - MODIFIED

PGM J407 VER 3.4
(REV 10/22/79)

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

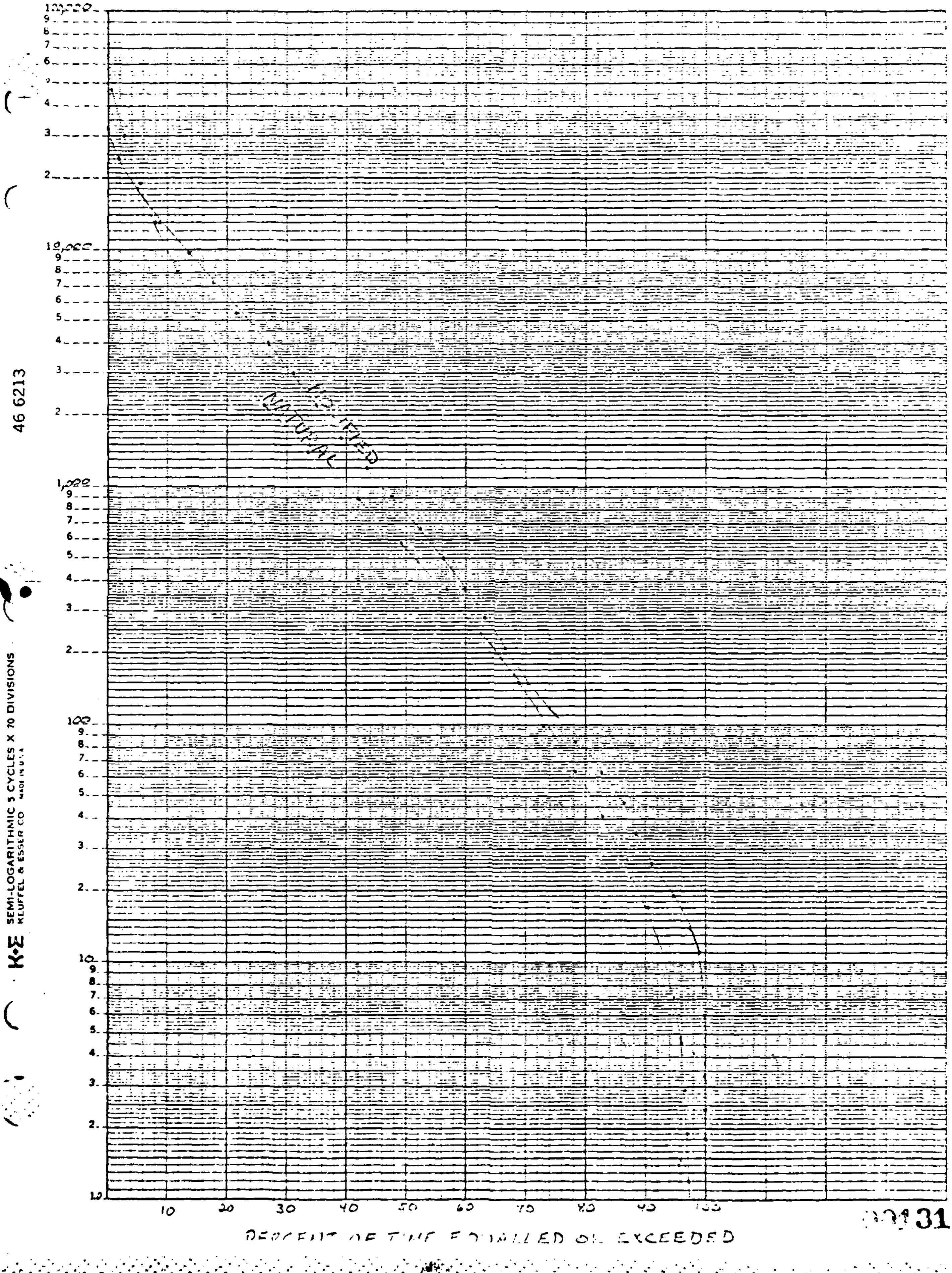
FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 3/80 AT 1557 SEQ 1.0001

STATION - 07171400/USGS VERDIGRIS RIVER NR OOLOGAH, OK 1963-1977 07171400/USGS



00130

OOLOGAH - VERDIGRIS R.



PERCENT OF TIME EQUALLED OR EXCEEDED

31

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980
WQ DATA 0.3 MILES BELOW OOLOGAH DAM

STN 1.SUMMARY.1

07171400
36 25 17.0 095 41 01.0 2
VERDIGRIS RIVER NR OOLOGAH, OK
40131 OKLAHOMA ROGERS
100391

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 74/01/03 TO 79/10/16

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	76	1	9	0	10	10	10	42	38	0
MEAN	15.40	0.115	8.44	0.	1.400	25.40	5.	9.443	0.264	0.0
MEDIAN	15.50	0.115	1.00	0.	1.000	14.50	4.	9.600	0.230	0.0
NO OF VIOLS	0	0	0	0	0	1	0	0	0	0
PERCENT VIOL	0.	0.	0.	0.	0.	10.	0.	0.	0.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.	0.0	143.00	0.	0.0	0.0	0.0
MEAN VIOL	0.0	0.0	0.0	0.	0.0	143.00	0.	0.0	0.0	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.	0.0	143.00	0.	0.0	0.0	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

0132

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 1.SUMMARY.2

IO DATA 0.3 MI. BELOW OOLOGAH DAM

07171.00
36 25 17.0 095 41 01.0 2
VERDIGRIS RIVER NR OOLOGAH, OK
40131 OKLAHOMA ROGERS
100391

TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 74/01/03 TO 79/10/16

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
O OF VALUES	10	0	9	0	55	55	6	10	10	31
EAN	13.30	0.0	0.622	0.0	7.658	7.659	2.333	2.00	24.	21.00
EDIAN	11.00	0.0	0.500	0.0	7.600	7.600	2.000	2.00	10.	10.00
O OF VIOLS	0	0	0	0	1	1	0	0	0	2
ERCENT VIOL	0.	0.	0.	0.	2.	2.	0.	0.	0.	6.
INIMUM VIOL	0.0	0.0	0.0	0.0	9.700	6.400	0.0	0.0	0.	60.00
EAN VIOL	0.0	0.0	0.0	0.0	9.700	6.400	0.0	0.0	0.	75.50
AXIMUM VIOL	0.0	0.0	0.0	0.0	9.700	6.400	0.0	0.0	0.	91.00
IN CRITERIA	*********	*********	*********	*********	*********	6.500	*********	*********	*********	*********
AX CRITERIA	50.00	50.00	2.000	10.000	9.000	*********	10.000	50.00	5000.	50.00

00133

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN. 2.SUMMARY.1
WQ DATA 0.5 MILES BELOW OOLOGAH DAM

21500U16X17Z39 07171400
36 25 17.0 095 41 01.0 2
VERDIGRIS RIVER NEAR OOLOGAH
40131 OKLAHOMA
ARKANSAS RIVER 1003
VERDIGRIS RIVER
21OKOSHD
0000 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 76/01/20 TO 80/07/29

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	50	1	11	0	12	12	12	50	46	0
MEAN	16.06	0.115	8.27	0.	1.417	22.42	5.	9.158	0.261	0.0
MEDIAN	16.50	0.115	1.00	0.	1.000	12.00	4.	9.000	0.225	0.0
NO OF VIOLS	0	0	0	0	0	1	0	0	0	0
PERCENT VIOL	0.	0.	0.	0.	0.	8.	0.	0.	0.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.	0.0	143.00	0.	0.0	0.0	0.0
MEAN VIOL	0.0	0.0	0.0	0.	0.0	143.00	0.	0.0	0.0	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.	0.0	143.00	0.	0.0	0.0	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

STORET RET[illegible]L DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STV 2.SUMMARY.2

WQ DATA 0.5 [illegible]ILES BELOW OOLOGAH DAM

21500U15X17232 07171400
36 25 17.0 095 41 01.0 2
VERDIGRIS RIVER NEAR OOLOGAH
40131 OKLAHOMA
ARKANSAS RIVER 1003
VERDIGRIS RIVER
21OK0SHD
0000 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 75/01/23 TO 80/07/29

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	12	0	11	0	49	49	8	12	12	50
MEAN	14.33	0.0	0.600	0.0	7.618	7.618	2.500	2.08	21.	19.09
MEDIAN	11.00	0.0	0.500	0.0	7.600	7.600	2.000	2.00	10.	13.50
NO OF VIOLS	0	0	0	0	2	1	0	0	0	3
PERCENT VIOL	0.	0.	0.	0.	4.	2.	0.	0.	0.	6.
MINIMUM VIOL	0.0	0.0	0.0	0.0	9.300	4.000	0.0	0.0	0.	58.00
MEAN VIOL	0.0	0.0	0.0	0.0	9.500	4.000	0.0	0.0	0.	69.67
MAXIMUM VIOL	0.0	0.0	0.0	0.0	9.700	4.000	0.0	0.0	0.	91.00
MIN CRITERIA	*********	*********	*********	*********	*********	6.500	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	9.000	*********	10.000	50.00	5000.	50.00

00135

1. Project Name: Hulah Lake

2. Project Location: River mile 96.2 on Caney River tributary to Verdigris River. Project watershed (732 square miles) located in Oklahoma and Kansas; downstream management control stations located in Oklahoma.

3. Type of Project:

a. General Category: Multiple-purpose storage reservoir (excluding hydropower).

b. Storage Allocations:

	Elevation feet (N.G.V.D.)	Storage Acre-feet	Storage Inches Runoff
Top Flood Control Pool	765.0	289,000	7.40
Top Conservation Pool	733.0	31,100	.80
Bottom Conservation Pool	710.0	0	0.00
Water Supply Storage (12.4 mgd)		19,800	
Water Quality Storage (4.5 mgd)		7,100	

4. Water Management Criteria:

a. Authorized Project Purpose: Flood control, water supply, low flow augmentation, and conservation purposes.

b. Water Use Contracts: Water storage - (2) - 11.2 mgd.

c. Interagency Agreements: None.

d. Informal Commitments: None.

e. System Regulation Objectives: The project is regulated in the system to control floods while retaining equivalent flood control capabilities with other projects in the system.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(b) Quantity: The lake provides storage for flow augmentation in times of drought.

(2) Negative Effects:

(a) Quality: Due to the basin morphometry, Hulah Lake stratifies only occasionally. Such weak and ephemeral stratification is not associated with water quality degradation.

(b) Quantity: The lake is operated under a water-level management plan aimed at fishery enhancement. This can cause tailwater fluctuations to be greater than normal.

b. Project Effect on Instream Flows:

(1) General: Discharge frequency and duration curves for the natural and modified conditions are attached.

(2) Positive Effects: A reduction of peak flow magnitudes and an increase of low flows have been caused by the project operation.

(3) Negative Effects: Historical data from Hulah tailwater stations were compared to Oklahoma Raw Water Supply Standards (See Attachments). These drinking water standards were used because Oklahoma has few numerical standards for other water classes. Turbidity was the only parameter which frequently exceeded standards. Approximately one-half of the 87 samples exceeded the limit.

(4) Cause of Negative Effects: Soils along the flood plain of the Caney River are tillable, but are predominately silty-clay loams which are highly erodible and colloidal. Thus, many of the particles may remain suspended in Hulah Lake and are discharged through the conduit.

c. Project Effects on System Regulation: The project has a significant effect on the Verdigris River system for both flood control and flow augmentation.

6. Constraints on Obtaining Instream Quantity and Quality Objectives: The flood control releases are determined by and limited to the requirements specified by the navigation taper needs.

7. Alternatives:

a. Reservoir Regulation: None.

b. Structural Modification: None.

c. Storage Reallocation: None.

d. Other: No action.

8. Action Taken to Date: None.

9. Planned Action: None.

HULAH
CANEY RIVER, OKLAHOMA AND KANSAS

Top of Conservation (Power) Pool Elevation	733
Top of Flood Control Pool Elevation	765

OUTLET WORKS

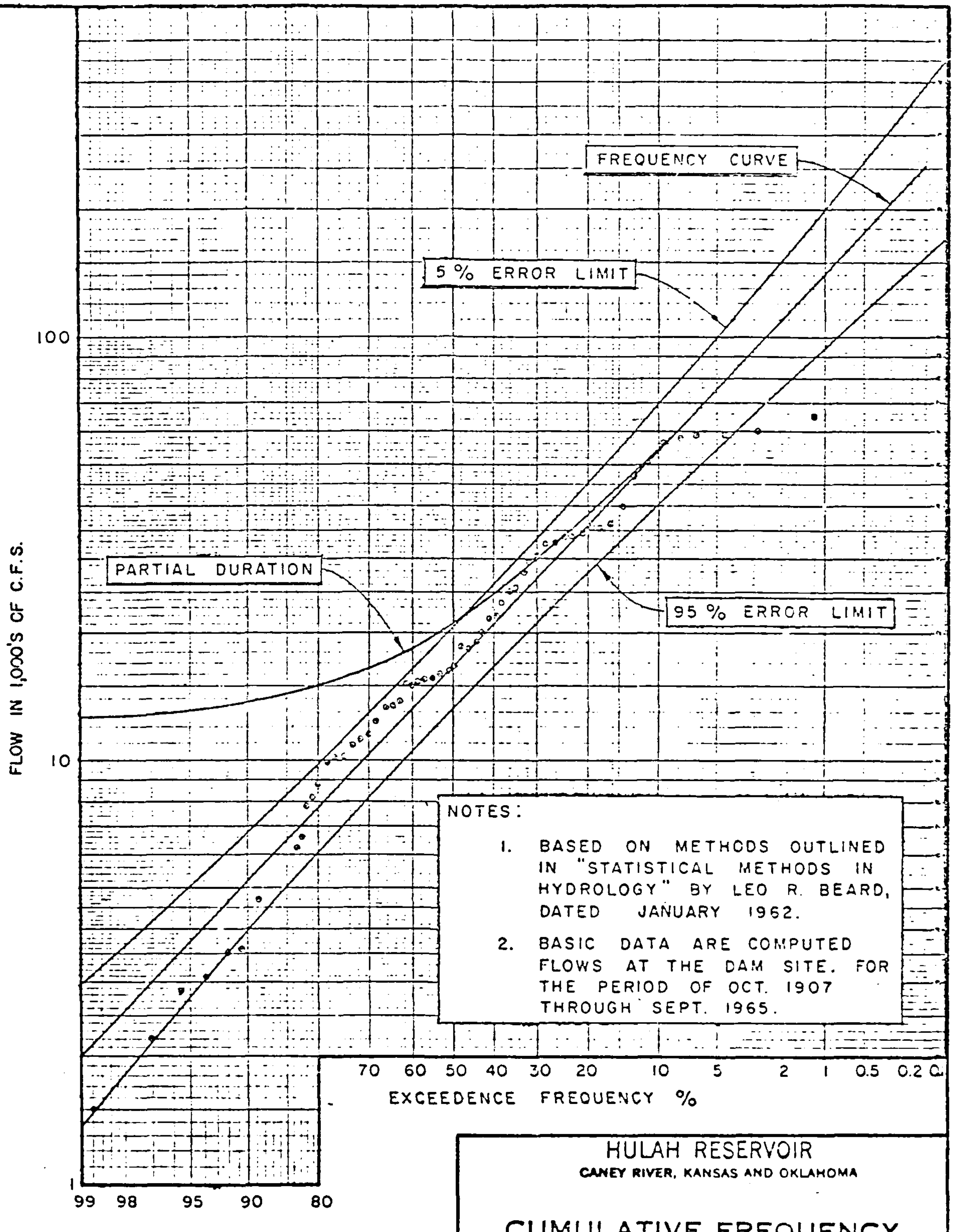
Type	Sluice
Size	9-5'x6.5'
Intake Elevation	702
Control Gates	9-5'x6.5'
Capacity at Conservation Pool (c.f.s.)	7950
Capacity at Flood Control Pool (c.f.s.)	12,400

WATER SUPPLY FACILITY

Low Flow	
Type	Pipe
Size	2-24" Dia.
Elevation	706
Capacity at Conservation Pool (c.f.s.)	170
Static Head Pipe	
Diameter	10" Dia.

SPILLWAY

Type	Ogee
Crest Width	400'
Crest Elevation	740
Control	10-40'x25' (Tainter Gates)
Capacity at Conservation Pool (c.f.s.)	0
Capacity at Flood Control Pool (c.f.s.)	184,000



NOTES:

1. BASED ON METHODS OUTLINED IN "STATISTICAL METHODS IN HYDROLOGY" BY LEO R. BEARD, DATED JANUARY 1962.
2. BASIC DATA ARE COMPUTED FLOWS AT THE DAM SITE, FOR THE PERIOD OF OCT. 1907 THROUGH SEPT. 1965.

HULAH RESERVOIR

CANEY RIVER, KANSAS AND OKLAHOMA

CUMULATIVE FREQUENCY CURVE OF ANNUAL PEAK FLOWS

NATURAL CONDITIONS

U. S. ARMY ENGINEER DIST., TULSA, CORPS OF ENGINEERS JUN 65
DRAWN: L. E. L.
CHECKED: D. R. H.

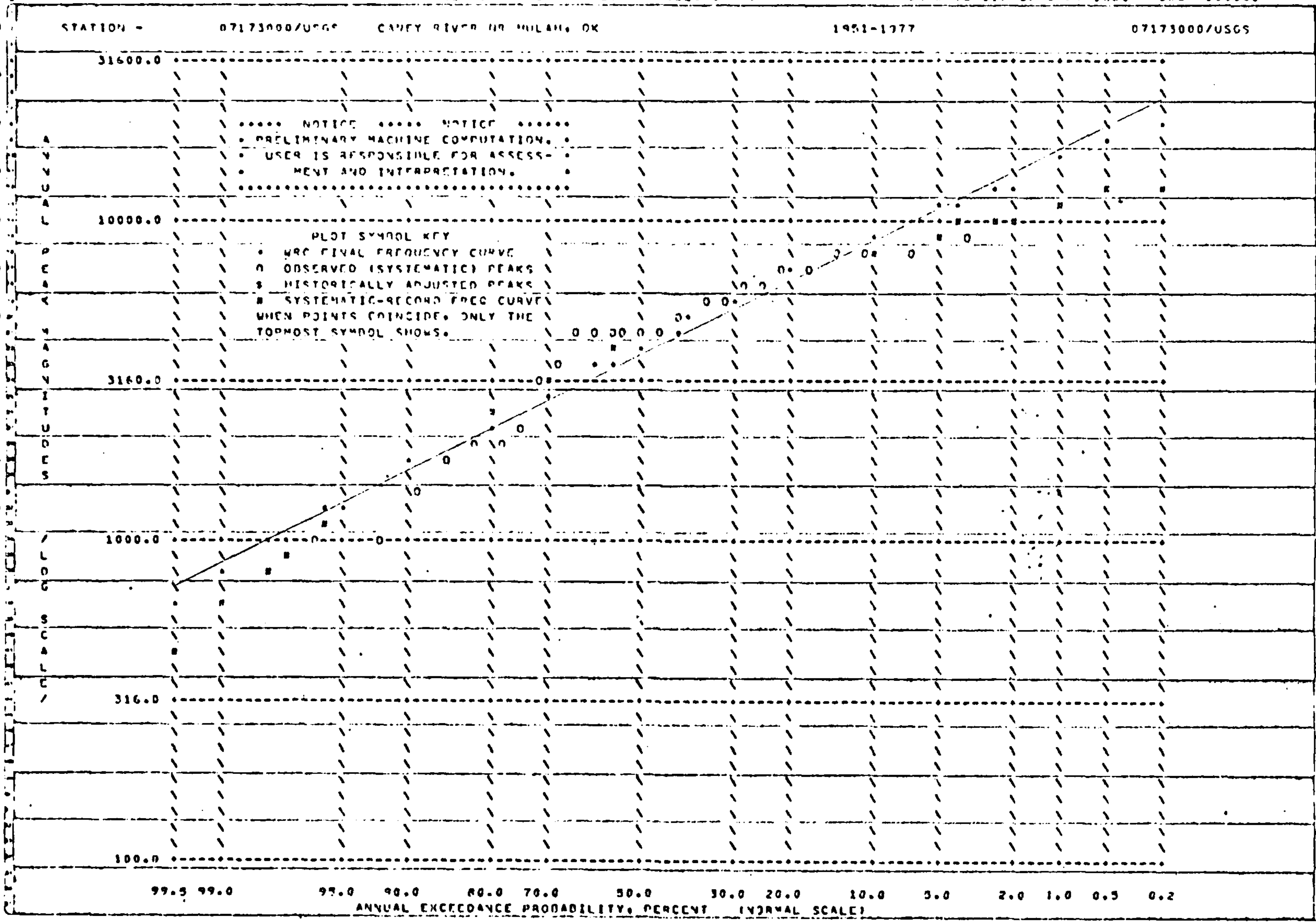
139

HULAH- MODIFIED

J407 VER 3.4
V 10/22/79)

U. S. GEOLOGICAL
ANNUAL PEAK FLOW FREQUE ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 3/80 AT 1521 SEQ 1.0001



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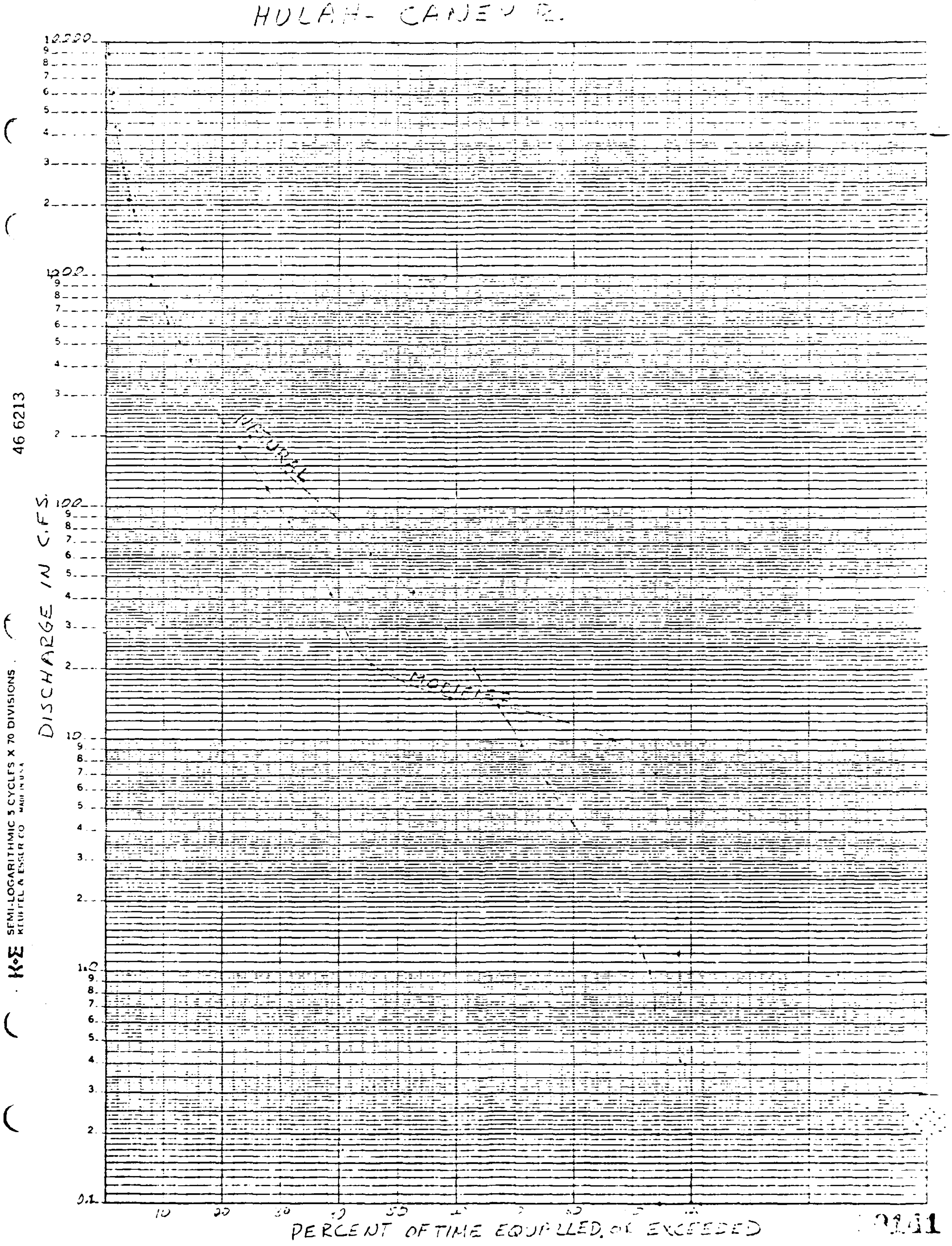


HULAH- CANEY R.
DISCHARGE IN C.F.S.
NATURAL
MODIFIED
PERCENT OF TIME EQUALLED OR EXCEEDED
SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
46 6213

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980

WQ DATA 0.2 MILES BELOW HULAH

07173000
36 55 06.0 096 04 15.0 2
CANEY RIVER NR HULAH, OK
40113 OKLAHOMA OSAGE
100391

STN 1.SUMMARY.1

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 51/11/09 TO 79/10/17

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	86	1	9	0	10	10	9	47	45	0
MEAN	14.92	4.000	3.22	0.	1.200	15.50	6.	10.062	0.457	0.0
MEDIAN	15.55	4.000	1.00	0.	1.000	11.50	4.	9.600	0.230	0.0
NO OF VIOLS	0	1	0	0	0	0	0	0	2	0
PERCENT VIOL	0.	100.	0.	0.	0.	0.	0.	0.	4.	0.
MINIMUM VIOL	0.0	4.000	0.0	0.	0.0	0.0	0.	0.0	2.500	0.0
MEAN VIOL	0.0	4.000	0.0	0.	0.0	0.0	0.	0.0	5.250	0.0
MAXIMUM VIOL	0.0	4.000	0.0	0.	0.0	0.0	0.	0.0	8.000	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

2942

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP, 1980 STV 1.SUMMARY.2

WQ DATA 0.2 MILES BELOW HULAH

07173000
36 55 06.0 096 04 15.0 2
CANEY RIVER NR HULAH, OK
40113 OKLAHOMA OSAGE
100391

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 51/11/03 TO 79/10/17

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	10	0	8	0	93	93	8	10	10	35
MEAN	9.60	0.0	1.062	0.0	7.870	7.870	1.875	1.50	12.	46.35
MEDIAN	9.50	0.0	0.500	0.0	8.000	8.000	1.500	1.50	14.	35.00
NO OF VIOLS	0	0	1	0	0	1	0	0	0	11
PERCENT VIOL	0.	0.	13.	0.	0.	1.	0.	0.	0.	31.
MINIMUM VIOL	0.0	0.0	5.000	0.0	0.0	6.000	0.0	0.0	0.	52.00
MEAN VIOL	0.0	0.0	5.000	0.0	0.0	6.000	0.0	0.0	0.	95.68
MAXIMUM VIOL	0.0	0.0	5.000	0.0	0.0	6.000	0.0	0.0	0.	275.00
MIN CRITERIA	*********	*********	*********	*********	*********	6.500	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	9.000	*********	10.000	50.00	5000.	50.00

STORET RETR DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 2.SUMMARY.1
WQ DATA 0.2 ..ES BELOW HULAH

21400H5X7215 07173000
36 55 06.0 096 04 15.0 2
CANEY RIVER NEAR HULAH
40113 OKLAHOMA
ARKANSAS RIVER 1003
VERDIGRIS RIVER
210KOSHD
0000 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 59/10/20 TO 80/07/29

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	51	1	13	0	13	13	12	50	47	0
MEAN	14.43	0.040	3.31	0.	1.231	13.69	5.	9.830	0.394	0.0
MEDIAN	15.00	0.040	1.00	0.	1.000	10.00	4.	9.550	0.210	0.0
NO OF VIOLS	0	0	0	0	0	0	0	0	1	0
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	0.	2.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	8.000	0.0
MEAN VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	8.000	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	8.000	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

30144

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STV 2.SUMMARY.2

WQ DATA 0.2 MILES BELOW HULAH

21400H5X7213 07173000
36 55 06.0 096 04 15.0 2
CANEY RIVER NEAR HULAH
40113 OKLAHOMA
ARKANSAS RIVER 1003
VERDIGRIS RIVER

/TYPA/AMBNT/STREAM

210KOSHO
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 59/10/20 TO 80/07/29

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	13	0	13	0	53	53	13	13	13	52
MEAN	12.62	0.0	1.654	0.0	7.841	7.841	1.692	1.69	11.	44.69
MEDIAN	10.00	0.0	0.500	0.0	7.900	7.900	1.000	2.00	9.	36.00
NO OF VIOLS	0	0	1	0	0	1	0	0	0	16
PERCENT VIOL	0.	0.	8.	0.	0.	2.	0.	0.	0.	31.
MINIMUM VIOL	0.0	0.0	12.000	0.0	0.0	6.000	0.0	0.0	0.	52.00
MEAN VIOL	0.0	0.0	12.000	0.0	0.0	6.000	0.0	0.0	0.	88.66
MAXIMUM VIOL	0.0	0.0	12.000	0.0	0.0	6.000	0.0	0.0	0.	275.00
MIN CRITERIA	*********	*********	*********	*********	*********	6.500	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	9.000	*********	10.000	50.00	5000.	50.00

1. Project Name: Copan Lake

2. Project Location: River mile 7.4 on Little Caney River tributary to Verdigris River. Project watershed (505 square miles) located in Oklahoma; downstream management control stations located in Oklahoma.

3. Type of Project:

a. General Category: Multiple-purpose storage reservoir (excluding hydropower).

b. Storage Allocations:

	Elevation Feet (N.G.V.D.)	Storage Acre-Feet	Inches Runoff
Top Flood Control Pool	732.0	227,700	8.45
Top Conservation Pool	710.0	43,400	1.61
Bottom Conservation Pool	687.5	600	.02
Water Supply Storage (3 mgd)		7,500	
Water Quality Storage (16 mgd)		26,100	

c. Hydropower Category: None.

4. Water Management Criteria:

a. Authorized Project Purposes: Flood control, water supply, water quality, recreation, and fish and wildlife.

b. Water Use Contracts: Pending water storage - 2 mgd.

c. Interagency Agreements: None.

d. Informal Commitments: None.

e. System Regulation Objectives: The project is regulated in the system to control floods and retain equivalent flood control capabilities with other projects in the system.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(b) Quantity: The lake provides storage for flow augmentation in times of drought.

(2) Negative effects:

Quality: Due to the basin morphometry, Copan Lake will probably stratify only occasionally. Such weak and ephemeral stratification is not associated with water quality degradation.

b. Project Effect on Instream Flows:

(1) General: Natural frequency and duration curves are attached. The project is still under construction as of November 1980.

(2) Positive Effects: Peak flow magnitudes will probably be decreased and low flows will be enhanced.

(3) Negative Effects: Water quality is expected to be good.

c. Project Effects on System Regulation: The project has a major flood controlling effect on the Caney River system but a minor effect on the Verdigris River.

6. Alternatives:

a. Reservoir Regulation: None.

b. Structural Modification: None.

c. Storage Reallocation: None.

d. Other: None.

7. Action Taken to Date: None.

8. Planned Action: None.

COPAN
LITTLE CANEY RIVER, OKLAHOMA AND KANSAS

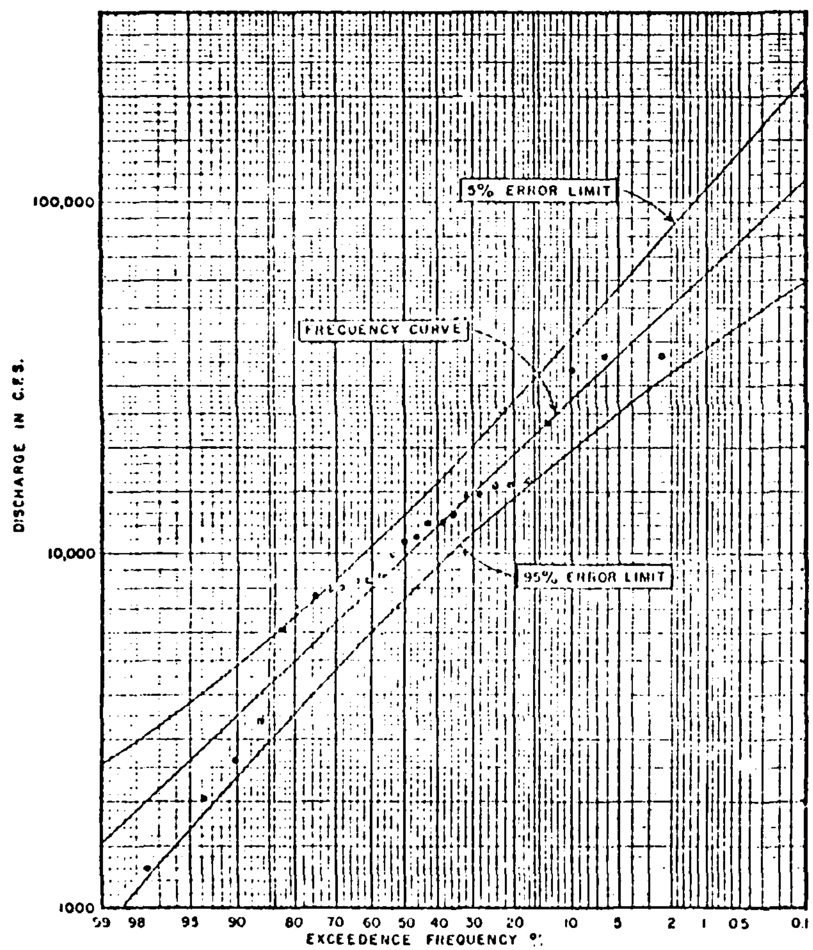
Top of Conservation (Power) Pool Elevation	710.0
Top of Flood Control Pool Elevation	732.0

WATER SUPPLY FACILITY

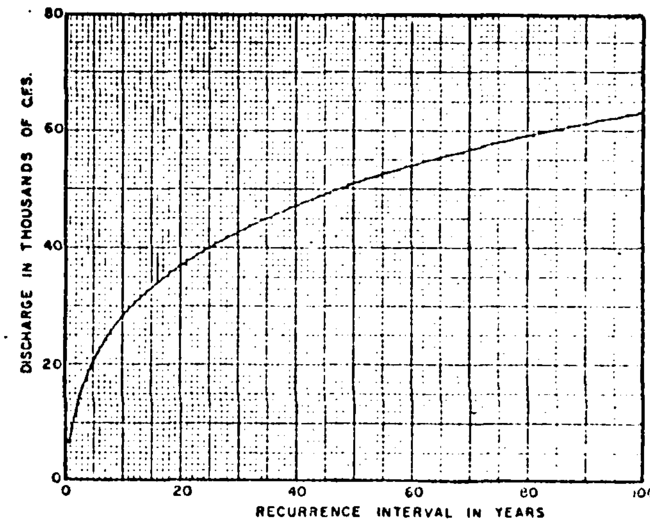
Low Flow	
Type	Pipe
Size	36" Dia.
Elevation	675.5
Capacity at Conservation Pool (c.f.s.)	210
Capacity at Flood Control Pool (c.f.s.)	270
Static Head Pipe	
Diameter	12" Dia.
Elevation	680.25

SPILLWAY

Type	Ogee
Crest Width	200'
Crest Elevation	696.5
Control	4-50'x35.5' (Tainter Gates)
Capacity at Conservation Pool (c.f.s.)	32,500
Capacity at Flood Control Pool (c.f.s.)	150,000



CUMULATIVE FREQUENCY CURVE OF ANNUAL PEAK FLOWS



DISCHARGE PROBABILITY UNDER NATURAL CONDITIONS

NOTES:

1. BASED ON METHODS OUTLINED IN "STATISTICAL METHODS IN HYDROLOGY" LEO R. BEARD, JAN. 1962
2. BASIC DATA ARE COMPUTED ANNUAL PEAK DISCHARGES AT THE DAM SITE FROM OCTOBER 1935 THROUGH SEPTEMBER 1962

COPAN RESERVOIR

LITTLE CANEY RIVER OKLAHOMA

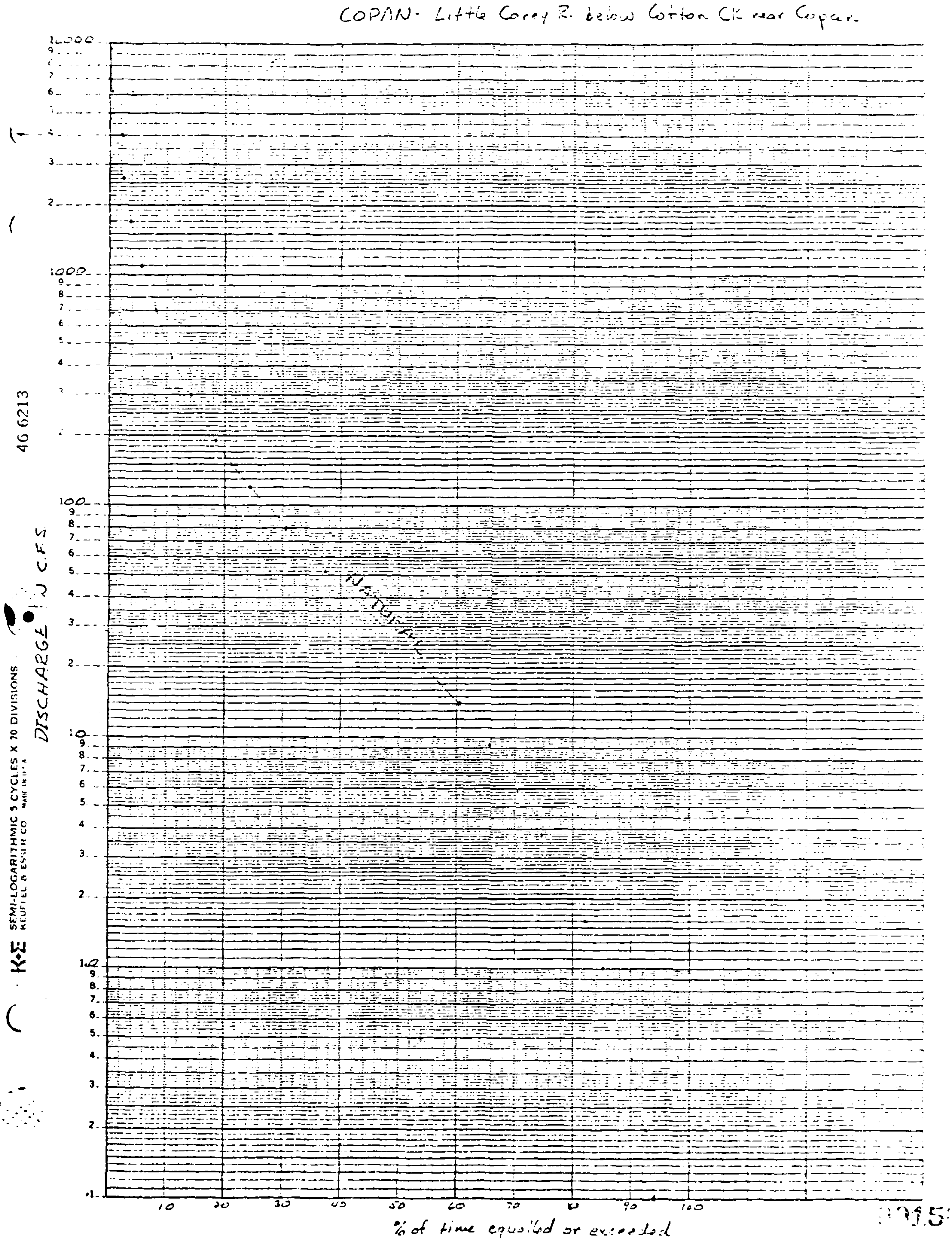
PEAK DISCHARGE FREQUENCY CURVES

NATURAL CONDITIONS

U. S. ARMY ENGINEER DIST., TULSA, CORPS OF | 18 MAY 64

DRAWN. D. A. F.

CHECKED B. B. B.


COPAN- Little Caney R. below Cotton Ck near Copan
DISCHARGE IN C.F.S.
NATURAL
% of time equalled or exceeded
K•E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 6213

1. Project Name: Birch Lake

2. Project Location: River Mile .8 on Birch Creek Tributary to Bird Creek. Project watershed (66 square miles) located in Oklahoma; downstream management control stations located in Oklahoma.

3. Type of Project:

a. General Category: Multiple-purpose storage reservoir (excluding hydropower)

b. Storage Allocations:

	Elevation Feet (N.G.V.D.)	Storage Acre-Feet	Storage Inches Runoff
Top Flood Control Pool	774.0	58,200	16.53
Top Conservation Pool	750.5	19,200	5.45
Bottom Conservation Pool	730.0	3,360	.95
Water Supply Storage (3 mgd)		7,600	
Water Quality Storage (3 mgd)		7,600	

4. Water Management Criteria:

a. Authorized Project Purpose: Flood control, water supply, water quality, recreation and fish and wildlife.

b. Water Use Contracts: Pending water storage - 2.5 mgd

c. Interagency Agreements: None

d. Informal Commitments: None

e. System Regulation Objectives: The project is regulated in the system to control floods while retaining equivalent flood control capabilities with other projects in the system.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(b) Quantity: The lake provides storage for flow augmentation in times of drought.

(2) Negative effects:

(a) Quality: Birch Lake becomes thermally stratified from early summer through mid-fall. Chemical reactions within the anoxic hypolimnion causes an increase in dissolved iron and manganese within this zone. The water in the hypolimnion decreases in pH and temperature while ammonia and hydrogen sulfide levels are elevated. When the lake returns to complete mixing in the fall, the water quality becomes more desirable.

(3) Causes of negative effects: Soils within the watershed are high in iron and manganese.

b. Project Effect on Instream Flows:

(1) General: Discharge frequency and duration curves for natural conditions are attached. The predicted modified duration curve is also attached.

(2) Negative effects: During flood operations, summertime releases may be low in dissolved oxygen and high in manganese, iron, and sulfides.

(3) Cause of negative effects: Conduit releases consist of hypolimnetic water when the lake is stratified.

c. Project Effects on System Regulation: The project has a major flood control effect on the Bird Creek system.

6. Constraints on Obtaining Instream Quantity and Quality Objectives: Unable to make selective water level withdrawals for flood releases.

7. Alternatives:

a. Reservoir Regulation: None

b. Structural Modification: A modification enabling surface waters to be withdrawn during flood operations would improve the quality of releases during stratified periods.

c. Storage Reallocation: None

d. Other: Destratification would improve the quality of flood releases.

e. No action.

8. Action Taken To Date: None

9. Planned Action: None

BIRCH
BIRCH CREEK, OKLAHOMA

Top of Conservation (Power) Pool Elevation	750.5
Top of Flood Control Pool Elevation	774.0

OUTLET WORKS

Type	Conduit
Size	7.5'x10.33'
Intake Elevation	711.0
Control Gates	2-3.75'x8.5'
Capacity at Conservation Pool (c.f.s.)	2240
Capacity at Flood Control Pool (c.f.s.)	2700

WATER SUPPLY FACILITY

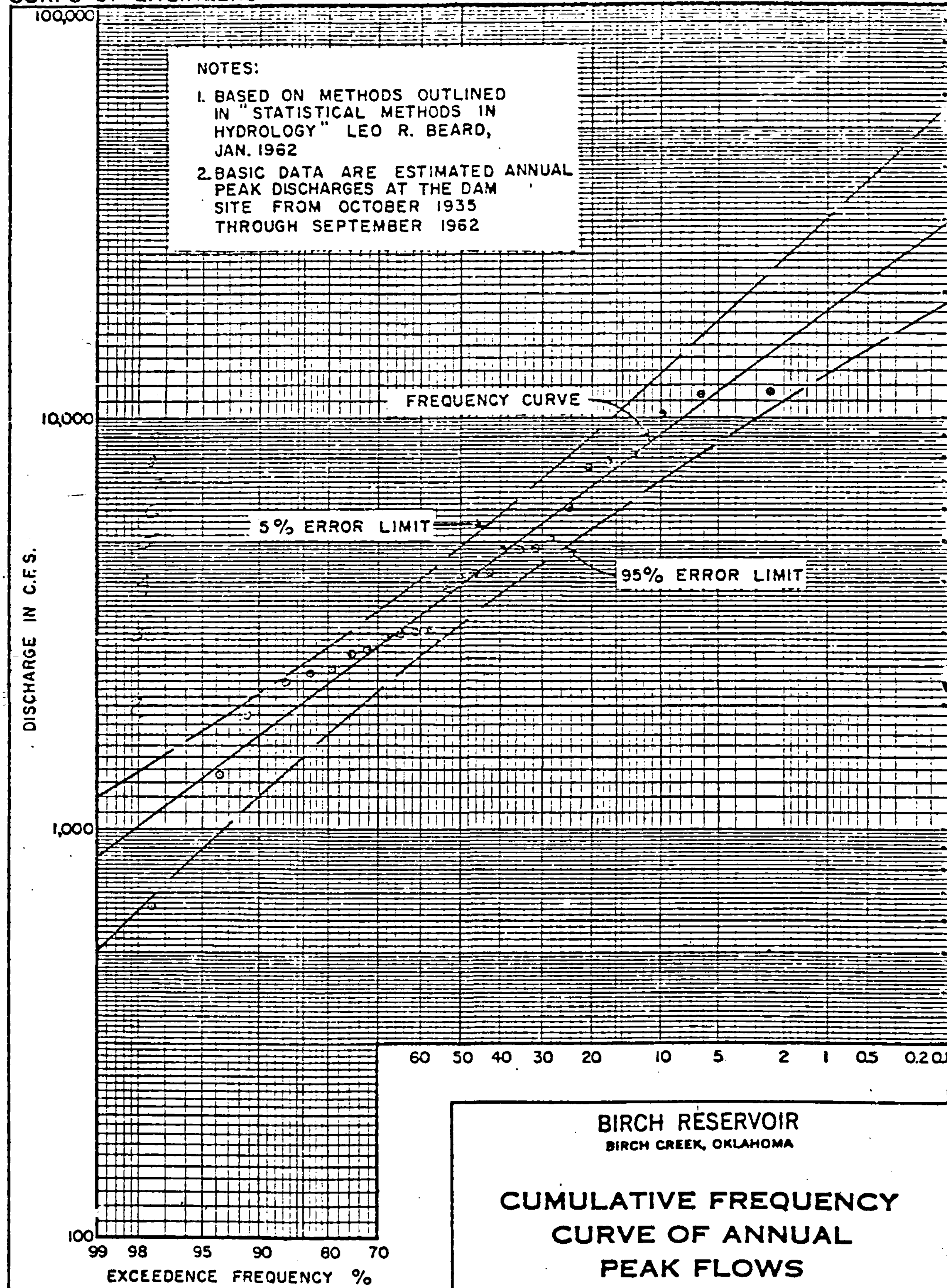
Intakes			
Number	1	1	1
Size	1.5'x1.5'	1.5'x1.5'	1.5'x1.5'
Elevation	743.0	735.0	727.5

Low Flow	
Type	Pipe
Size	12" Diameter
Elevation	725.0
Capacity at Conservation Pool (c.f.s.)	22

Static Head Pipe	
Diameter	12" Diameter
Elevation	725.0

SPILLWAY

Type	Excavated
Crest Width	135'
Crest Elevation	774.0
Control	Uncontrolled
Capacity at Conservation Pool (c.f.s.)	0
Capacity at Flood Control Pool (c.f.s.)	0



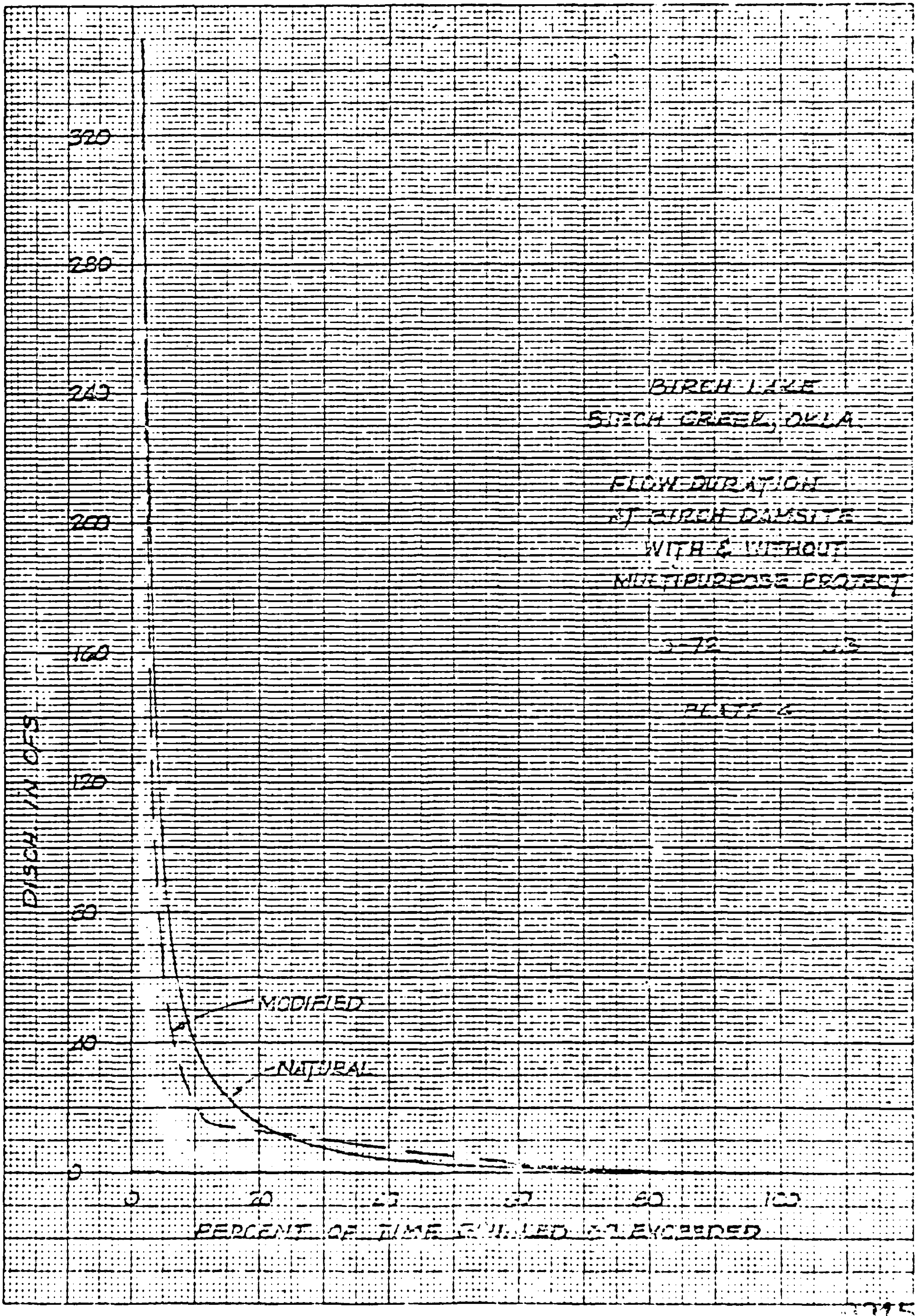
BIRCH RESERVOIR
BIRCH CREEK, OKLAHOMA

CUMULATIVE FREQUENCY CURVE OF ANNUAL PEAK FLOWS

U. S. ARMY ENGINEER DIST., TULSA, CORPS OF ENGINEERS OCT. 63

DRAWN: W. R. W.

CHECKED: B. G. B.


BIRCH
FLOW DURATION
WITH &
DISCH IN CFS
320
280
200
160
120
80
40
0
MODIFIED
NATURAL
0
20
100
PERCENT OF TIME
EXCEEDED

1. Project Name: Skiatook Lake

2. Project Location: River mile 14.3 on Hominy Creek tributary to Bird Creek. Project watershed (35.4 square miles) located in Oklahoma; downstream management control stations located in Oklahoma and Arkansas.

3. Type of Project:

a. General Category: multiple-purpose storage reservoir (excluding hydropower).

b. Storage Allocations:

	Elevation (feet N.G.V.D.)	Storage Acre-feet	Storage Inches of Runoff
Top Flood Control Pool	729.0	513,500	27.20
Top Conservation Pool	714.0	331,200	17.54
Bottom Conservation Pool	657.0	11,800	.62
Water Supply Storage (14 mgd)		64,600	
Water Quality Storage (62 mgd)		239,100	

4. Water Management Criteria:

a. Authorized Project Purpose: flood control, water supply, water quality, recreation, and fish and wildlife

b. Water Use Contracts: Pending water storage - 0.45 mgd

c. Interagency Agreements: None

d. Informal Commitments: None

e. System Regulation Objectives: The project is regulated in the system to control floods while retaining equivalent flood control capabilities with other projects in the system.

5. Project Evaluation:

a. Effects of impoundment on water stored:

1. Positive effects:

a. Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

b. Quantity: The lake provides storage for flow augmentation in times of drought.

2. Negative effects:

a. Quality: Skiatook Lake will probably become thermally stratified from early summer through mid-fall. Chemical reactions within the anoxic hypolimnion may cause an increase in dissolved iron and manganese within this zone. The water in the hypolimnion may decrease in pH and temperature while ammonia and hydrogen sulfide levels are elevated. When the lake returns to complete mixing in the fall, the water quality becomes more desirable.

3. Cause of negative effects: Soils within the watershed are high in iron and manganese. Agricultural operations lead to large input of these soils to the lake.

6. Project Effect on Instream Flows:

1. General: The natural frequency curve is attached with the duration curves for the natural and the predicted modified conditions.

2. Positive effects: Low flow durations have been increased. Reductions in peak flow magnitudes have been observed.

3. Negative effects: No water quality problems are expected.

4. Project effects on system regulation: The project will provide major flood protection on Bird Creek in the Tulsa area.

7. Constraints on Obtaining Instream Quantity and Quality Objectives: Unable to make selective water level withdrawals for flood releases.

8. Alternatives:

a. Reservoir Regulation: None

b. Structural Modification: None

c. Storage Reallocation: None

d. Other: No action.

9. Action Taken to Date: None

10. Planned Action: None

SKIATOOK
HOMINY CREEK, OKLAHOMA

Top of Conservation (Power) Pool Elevation	714.0
Top of Flood Control Pool Elevation	729.0

OUTLET WORKS

Type	Tunnel
Size	10.5' Dia.
Intake Elevation	620.0
Control Gates	2-4.67'x10.5'
Capacity at Conservation Pool (c.f.s.)	4100
Capacity at Flood Control Pool (c.f.s.)	4400

WATER SUPPLY FACILITY

Intakes

Number	2	1	1	1	1	2
Size	5'x8'	5'x5'	5'x5'	5'x5'	5'x5'	5'x5'
Elevation	704.0	693.0	685.0	675.0	665.0	646.0

Low Flow

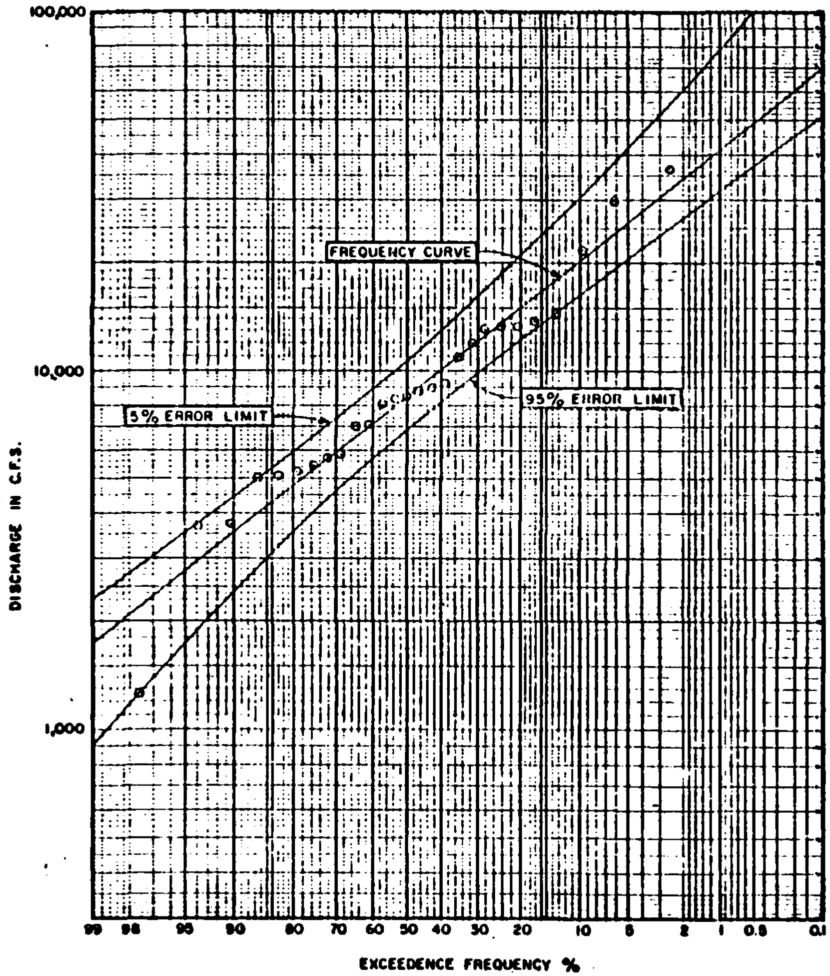
Type	Sluice
Size	2.5'x5.0'
Elevation	635.0
Capacity at Conservation Pool (c.f.s.)	685

Static Head Pipe

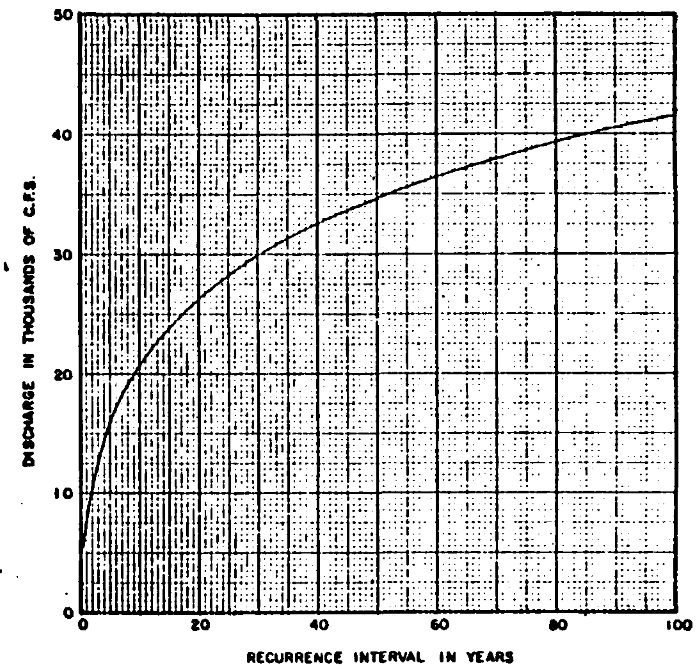
Diameter	36" Dia.
Elevation	614.5

SPILLWAY

Type	Excavated
Crest Width	100'
Crest Elevation	732.0
Control	Uncontrolled
Capacity at Conservation Pool (c.f.s.)	0
Capacity at Flood Control Pool (c.f.s.)	0



CUMULATIVE FREQUENCY CURVE



DISCHARGE PROBABILITY

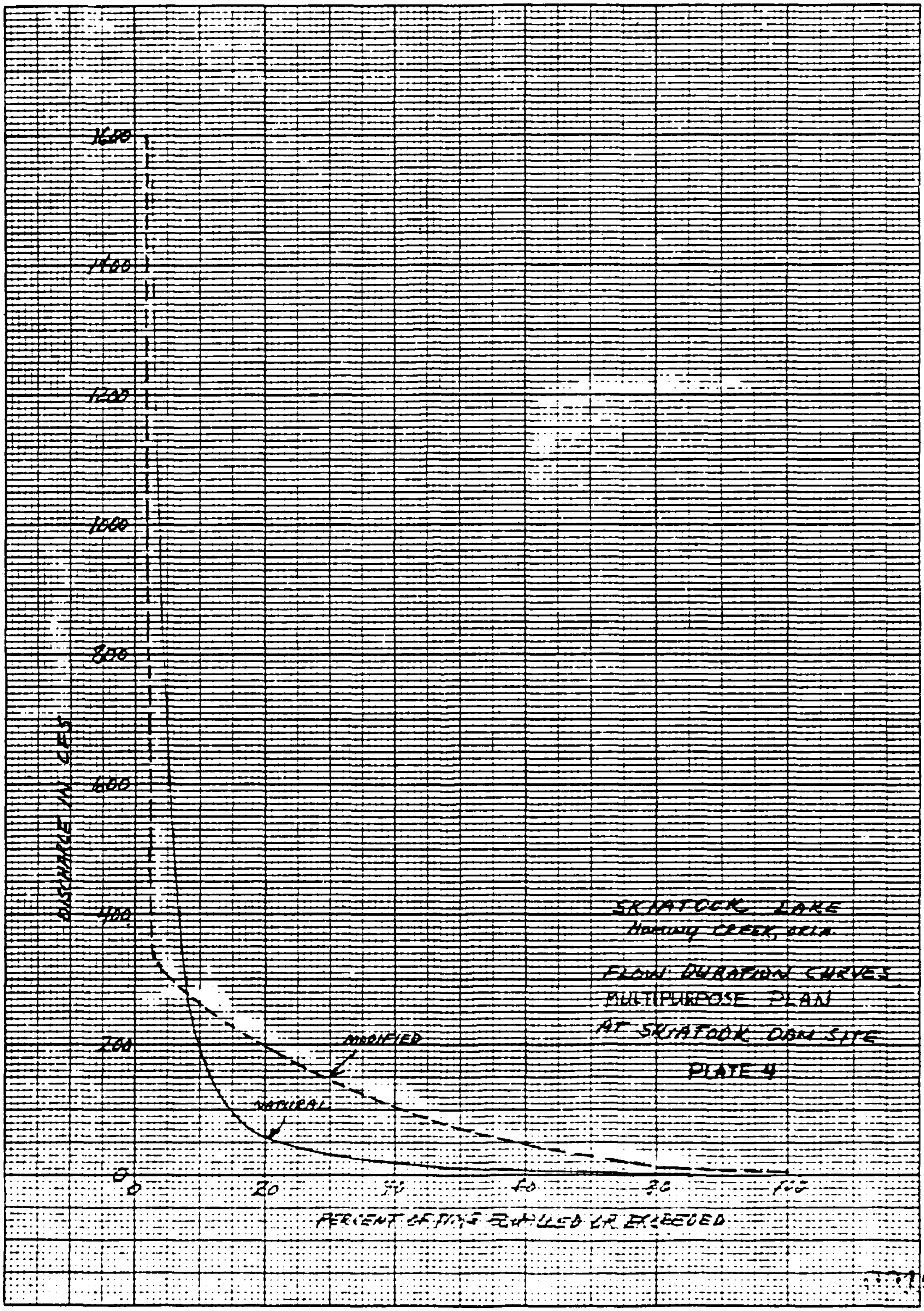
NOTES:
1. BASED ON METHODS OUTLINED IN "STATISTICAL METHODS IN HYDROLOGY" LEO R. BEARD, JAN. 1962
2. BASIC DATA ARE COMPUTED ANNUAL PEAK DISCHARGES AT THE DAM SITE FROM OCTOBER 1935 THROUGH SEPTEMBER 1962

SKIATOOK RESERVOIR
HOMINY CREEK, OKLAHOMA

CUMULATIVE FREQUENCY CURVE OF ANNUAL PEAK FLOWS AND DISCHARGE PROBABILITY UNDER NATURAL CONDITIONS

U. S. ARMY ENGINEER DIST., TULSA, CORPS OF ENGINEERS MAR 64
DRAWN: W.R.W.
CHECKED: S.S.S.
1103-DM1-99/5

PLATE 7



SKIATOOK LAKE
Hominy Creek, Okla.
FLOW DURATION CURVES
MULTIPURPOSE PLAN
AT SKIATOOK DAM SITE
PLATE 4
DISCHARGE IN CFS
1600
1400
1200
1000
800
600
400
200
0
0
20
40
60
80
100
PERCENT OF TIME EQUALLED OR EXCEEDED
MODIFIED
NATURAL

1. Project Name: Newt Graham Lock and Dam

2. Project Location: River Mile 26.7 on Verdigris River Tributary to Arkansas River. Project watershed located in Oklahoma.

3. Type of Project:

a. General Category: Navigation (excluding hydropower)

b. Storage Allocations:

	Elevation Feet (N.G.V.D.)	Storage Acre-Feet	Storage Inches Runoff
Top of Upper Pool	532.0	--	--
Top of Lower Pool	511.0		

c. Hydropower Category: None

4. Water Management Criteria:

a. Authorized Project Purpose: Navigation

b. Water Use Contracts: None

c. Interagency Agreements: None

d. Informal Commitments: None

e. System Regulation Objectives: The project is basically a run-of-river project that has only minor regulating abilities.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored: No significant effects are caused by this type of impoundment on the quality of the water.

b. Effects on Instream Flows: No significant effects are caused by this type of impoundment on the quality or quantity of flows.

c. Project Effects on System Regulation: The project provides for navigation on the Arkansas River system.

6. Alternatives:

a. Reservoir Regulation: None

b. Structural Modification: None

c. Storage Reallocation: None

d. Other: No action.

7. Action Taken To Date: None

8. Planned Action: None

1. Project Name: Chouteau Lock and Dam

2. Project Location: River Mile 6.5 on Verdigris River tributary to Arkansas River. Project watershed located in Oklahoma.

3. Type of Project:

a. General Category: Navigation (excluding hydropower).

b. Storage Allocations:

	Elevation Feet (N.G.V.D.)	Storage Acre-Feet	Storage Inches Runoff
Top Upper Pool	511.0	---	--
Top Lower Pool (normal)	490.0	---	--

c. Hydropower Category: None

4. Water Management Criteria:

a. Authorized Project Purpose: Navigation

b. Water Use Contracts: None

c. Interagency Agreements: None

d. Informal Commitments: None

e. System Regulation Objectives: The project is basically a run-of-river project that has only minor regulating abilities.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored: No significant effects are caused by this type of impoundment on the quality of the water.

b. Effects on Instream Flows: No significant effects are caused by this type of impoundment on the quality or quantity of flows.

c. Project Effects on System Regulation: The project provides for navigation on the Arkansas River system.

6. Alternatives:

a. Reservoir Regulation: None

b. Structural Modification: None

c. Storage Reallocation: None

d. Other: No action

7. Action Taken To Date: None

8. Planned Action: None

1. Project Name: Council Grove.

2. Project Location: River mile 449.9 on Grand (Neosho) River tributary to Arkansas River. Project watershed (246 square miles) located in Kansas; downstream management control stations located in Kansas.

3. Type of Project:

a. General Category: multiple-purpose storage reservoir (excluding hydropower).

b. Storage Allocations:

	Elevation (Feet N.G.V.D.)	Storage Ac. Ft.	Storage Inches of Runoff
Top Flood Control Pool	1289.0	112,265	8.55
Top Conservation Pool	1274.0	48,500	3.69
Bottom Conservation Pool	1240.0	14	
Water Supply Storage (6 mgd)		24,400	
Water Quality Storage (4.3 mgd)		17,500	

4. Water Management Criteria:

a. Authorized Project Purposes: flood control, water supply, water quality, and recreation.

b. Water Use Contracts: Water storage 6 mgd.

c. Interagency Agreements: The state of Kansas contracts for all the water supply storage available. Agreement with Kansas State Fish & Wildlife Dept. for pool level manipulation.

d. Informal Commitments: None.

e. System Regulation Objectives: Regulated in a system with John Redmond and Marion where releases from the system can only be made from John Redmond. Operated to retain equivalent flood control capabilties in so far as possible.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive Effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(b) Quantity: The lake provides storage for flow augmentation in times of drought.

(2) Negative Effects:

Quality: Due to the basin morphometry, Council Grove Lake stratifies only occasionally. Such weak and ephemeral stratification is not associated with water quality degradation.

b. Project Effect on Instream Flows:

(1) General: Discharge frequency and duration curves are attached (both natural and modified conditicns).

(2) Positive Effects: Reduction in peak flows and increases in low flows have been deserved since impoundment.

(3) Negative Effects: Historical data from Council Grove tailwater stations were compared to Kansas Class A water quality standards (see attachments). No significant violations of these standards were found, however, no data were available for many parameters. The lake is operated under a water level management plan aimed at enhancing the fishery. This can cause tailwater fluctuations to be greater than normal.

c. Project Effects on System Regulation: The project adds a significant flood control capabiltiy to the Grand (Neosho) River.

7. Alternatives:

a. Reservoir Regulation: None.

b. Structural Modification: None.

c. Storage Reallocation: None.

d. Other: No action.

8. Action Taken to Date: None.

9. Planned Action: None.

COUNCIL GROVE
GRAND (NEOSHO) RIVER, KANSAS

Top of Conservation (Power) Pool Elevation	1274.0
Top of Flood Control Pool Elevation	1289.0

OUTLET WORKS

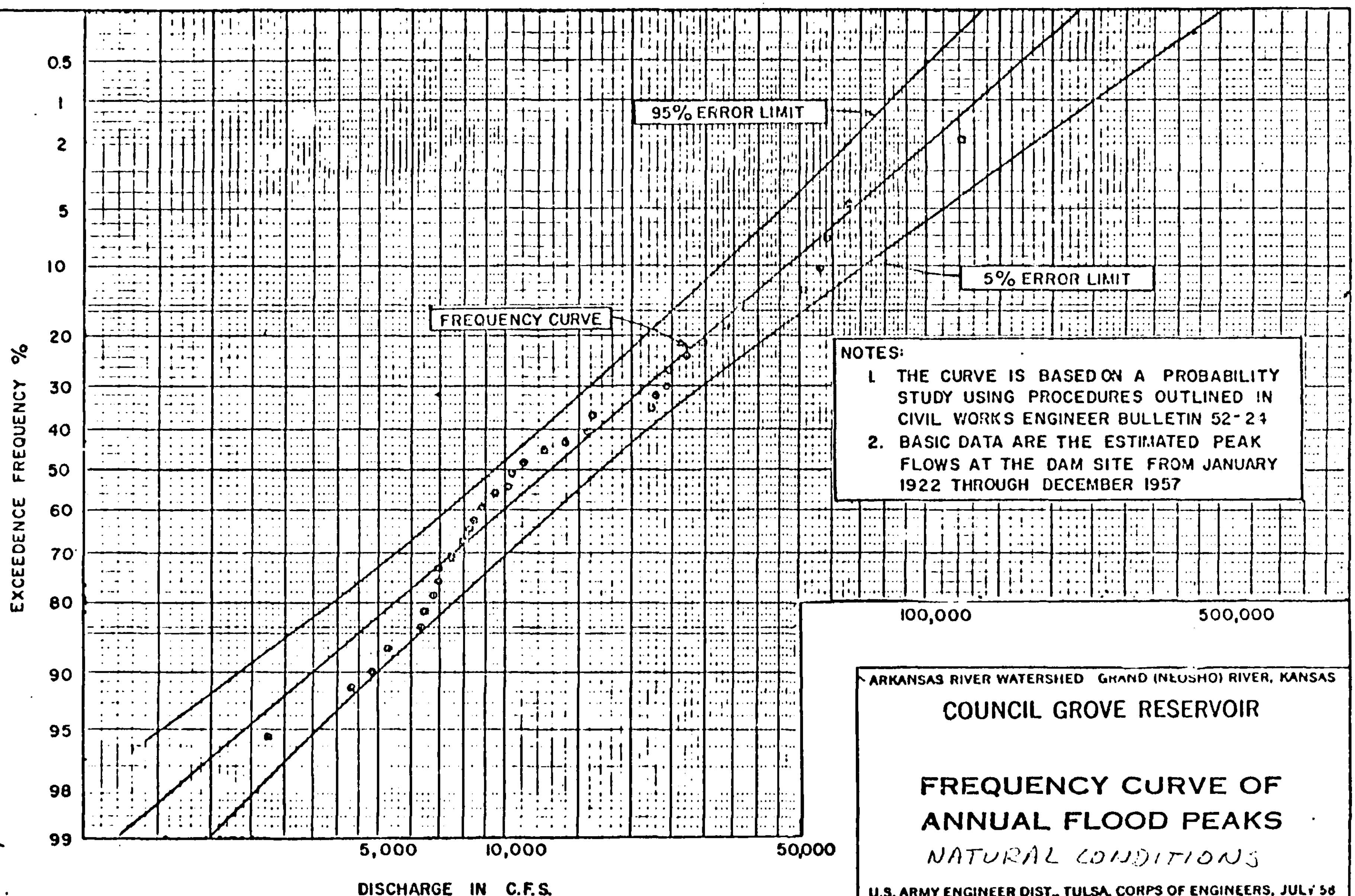
Type	Conduit
Size	17.0' Dia.
Intake Elevation	1223.0
Control Gates	2-7.5'x17'
Capacity at Conservation Pool (c.f.s.)	9900
Capacity at Flood Control Pool (c.f.s.)	11,400

WATER SUPPLY FACILITY

Low Flow	
Type	Pipe
Size	24" Dia.
Elevation	1229.5
Capacity at Conservation Pool (c.f.s.)	103
Static Head Pipe	
Diameter	24" Dia.
Elevation	1235.0

SPILLWAY

Type	Excavated
Crest Width	500'
Crest Elevation	1306.0
Control	Uncontrolled
Capacity at Conservation Pool (c.f.s.)	0
Capacity at Flood Control Pool (c.f.s.)	0



ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER, KANSAS

COUNCIL GROVE RESERVOIR

FREQUENCY CURVE OF ANNUAL FLOOD PEAKS

NATURAL CONDITIONS

U.S. ARMY ENGINEER DIST., TULSA, CORPS OF ENGINEERS, JULY 58

DRAWN: C.V.S.
CHECKED: G.C.K.

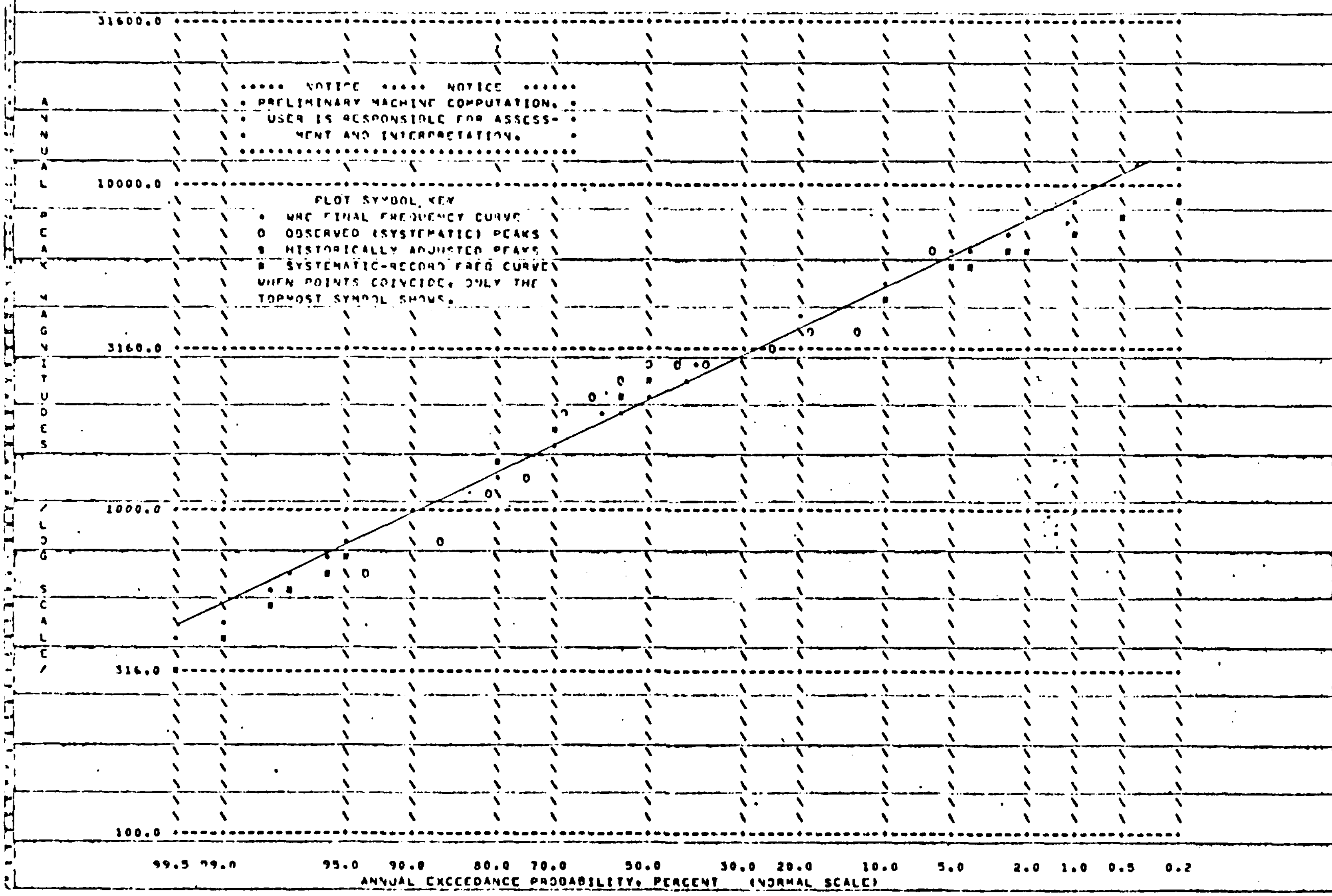
MODIFIED COUNCIL GROVE

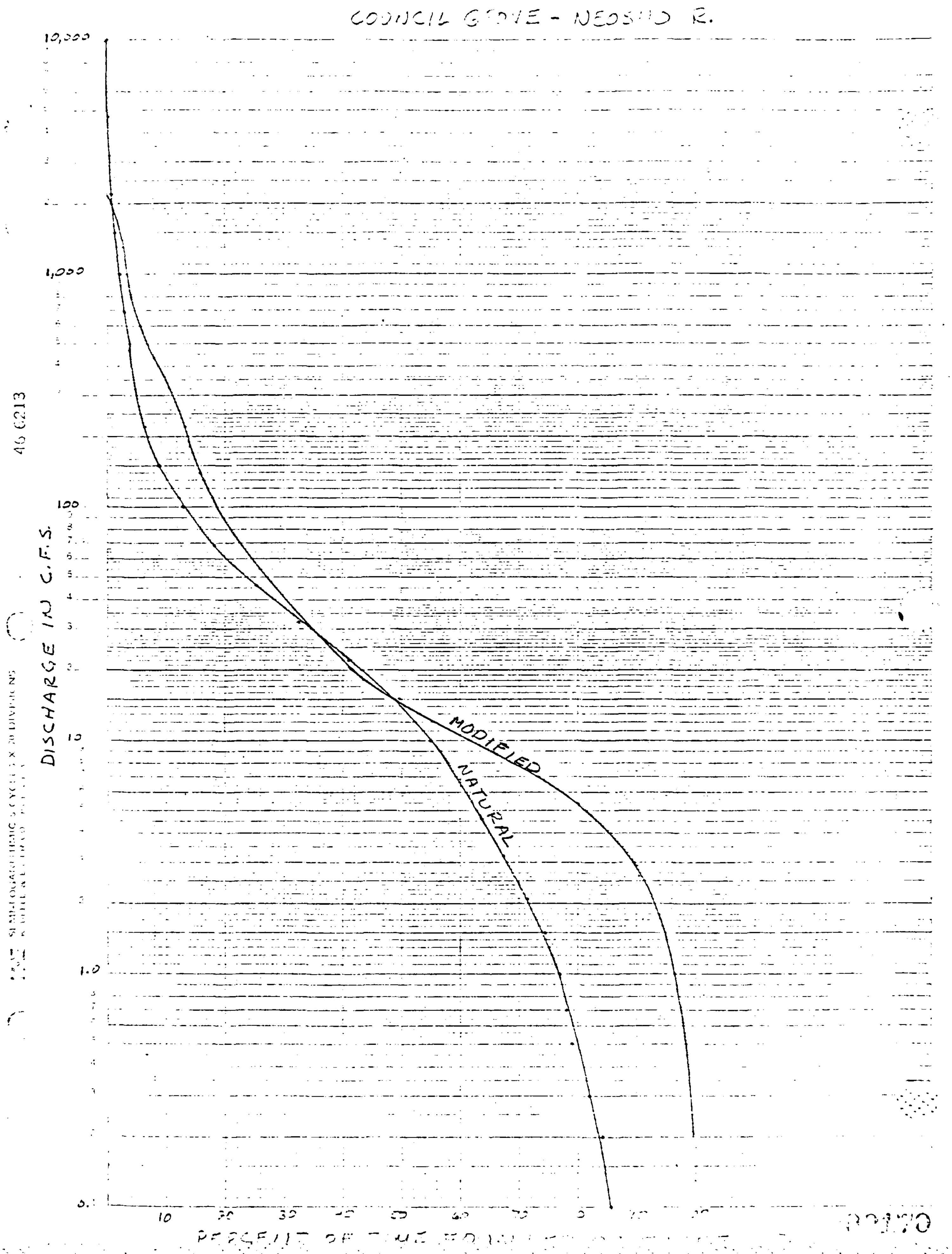
PGM J407 VER 3.4 10/22/79)

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 3/80 AT 1436 SEQ 1.00

STATION - 07179500/USGS NEOSHO R AT COUNCIL GROVE, KS 1965-1979 07179500/USGS




COUNCIL GROVE - NEOSHO R.
DISCHARGE IN C.F.S.
10,000
1,000
100
10
1.0
0.1
10
20
30
40
50
60
70
MODIFIED
NATURAL
46 6213

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 1.SUMMARY.1
WQ DATA 1 MILE… …OW COUNCIL GROVE

07 0
38 … .0 096 29 39.0 2
NEOSHO R AT COUNCIL GROVE, KS
20127 KANSAS
100491

TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 70/10/05 TO 79/03/20

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
O OF VALUES	59	0	0	0	0	0	0	0	0	0
EAN	13.29	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
EDIAN	13.50	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
O OF VIOLS	0	0	0	0	0	0	0	0	0	0
ERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
INIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
EAN VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
AXIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
IN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
AX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 1.SUMMARY.2

W3 DATA 1 MILES BELOW COUNCIL GROVE

07179500
38 39 54.0 096 29 39.0 2
NEOSHO R AT COUNCIL GROVE, KS
20127 KANSAS
100491

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 70/10/05 TO 79/03/20

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	0	0	0	0	57	57	0	0	0	22
MEAN	0.0	0.0	0.0	0.0	7.640	7.640	0.0	0.0	0.	81.32
MEDIAN	0.0	0.0	0.0	0.0	7.700	7.700	0.0	0.0	0.	57.50
NO OF VIOLS	[illegible]	0	0	0	0	0	0	0	0	11
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	0.	0.	50.
MINIMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	65.00
MEAN VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	142.73
MAXIMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	450.00
MIN CRITERIA	*********	*********	*********	*********	6.500	*********	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	*********	8.500	10.000	50.00	5000.	50.00

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 2.SUMMARY.1
WQ DATA 1 MI BELOW COUNCIL GROVE

3. 54.0 096 29 38.0 5
NEOSHO R.BELOW COUNCIL GROVE DAM
20127 KANSAS
ARKANSAS
NEOSHO UNIT
21KAN001 760325
0000 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 75/11/11 TO 80/01/22

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	44	44	0	0	0	0	0	43	0	0
MEAN	12.05	0.221	0.0	0.	0.0	0.0	0.	9.537	0.0	0.0
MEDIAN	10.50	0.190	0.0	0.	0.0	0.0	0.	8.900	0.0	0.0
NO OF VIOLS	0	2	0	0	0	0	0	0	0	0
PERCENT VIOL	0.	5.	0.	0.	0.	0.	0.	0.	0.	0.
MINIMUM VIOL	0.0	0.590	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MEAN VIOL	0.0	0.605	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MAXIMUM VIOL	0.0	0.620	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

2223

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 2.SUMMARY.2
WQ DATA 1 MILES BELOW COUNCIL GROVE

000097
38 39 54.0 096 29 38.0 5
NEOSHO R.BELOW COUNCIL GROVE DAM
20127 KANSAS
ARKANSAS
NEOSHO UNIT
21KAN001 760326
0000 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 75/11/11 TO 80/01/22

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	0	0	6	0	0	0	0	0	0	0
MEAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.0
MEDIAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.0
NO OF VIOLS	0	0	0	0	0	0	0	0	0	0
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.0
MEAN VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.0
MIN CRITERIA	*********	*********	*********	*********	6.500	*********	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	*********	8.500	10.000	50.00	5000.	50.00

1. Project Name: Marion Lake

2. Project Location: River mile 126.7 on Cottonwood River tributary to Grand River. Project watershed (200 square miles) located in Kansas; downstream management control stations location in Kansas.

3. Type of Project:

a. General Category: multiple-purpose storage reservoir (excluding hydro power).

b. Storage Allocations:

	Elevation (feet N.G.V.D.)	Storage Acre-Feet	Storage Inches of Runoff
Top Flood Control Pool	1358.5	143,850	13.49
Top Conservation Pool	1350.5	83,690	7.85
Bottom Conservation Pool	1320.0	365	.03
Water Supply Storage (3 mgd)		38,300	
Water Quality Storage (3.5 mgd)		44,600	

4. Water Management Criteria:

a. Authorized Project Purpose: flood control, water supply, water quality and recreation

b. Water Use Contracts: Water Storage 3 mgd.

c. Interagency Agreements: The State of Kansas contracts for all the water supply storage available. Agreement with Kansas State Fish and Wildlife Department for pool level manipulation.

d. Informal Commitments: None

e. System Regulation Objectives: The project is regulated in a system with John Redmond and Council Grove where releases can only be made from John Redmond. The project is operated to retain equivalent flood control capabilities.

5. Project Evaluation:

a. Effects of impoundment on water stored:

(1) Positive effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(b) Quantity: The lake provides storage for flow augmentation in times of drought.

(2) Negative Effects:

(a) Quality: Due to the basin morphometry, Marion Lake stratifies only occasionally. Such weak and ephemeral stratification is not associated with water quality degradation.

(b) Quantity: The lake is operated under a water level management plan aimed at enhancing the fishery. This can cause tailwater fluctuations to be greater than normal.

6. Project Effects on Instream Flows:

(1) General: Discharge frequency and duration curves for natural and modified conditions are attached.

(2) Positive Effects: The magnitude of the peak discharges have been reduced. The project supplies flow augmentation for the Grand (Neosho) River.

(3) Negative Effects: Historical data from Marion tailwater stations were compared to Kansas Class A water quality standards (see attachments). No significant violations of these standards were found, however, no data were available for many parameters.

(4) Project Effects on System Regulation: The project has minimal flood control capabilities on the Grand (Neosho) River but has significant effects on the Cottonwood River.

7. Alternatives:

a. Reservoir Regulation: None

b. Structural Modification: None

c. Storage Reallocation: None

d. Other: No action

8. Action Taken to Date: None

9. Planned Action: None

MARION
COTTONWOOD RIVER, KANSAS

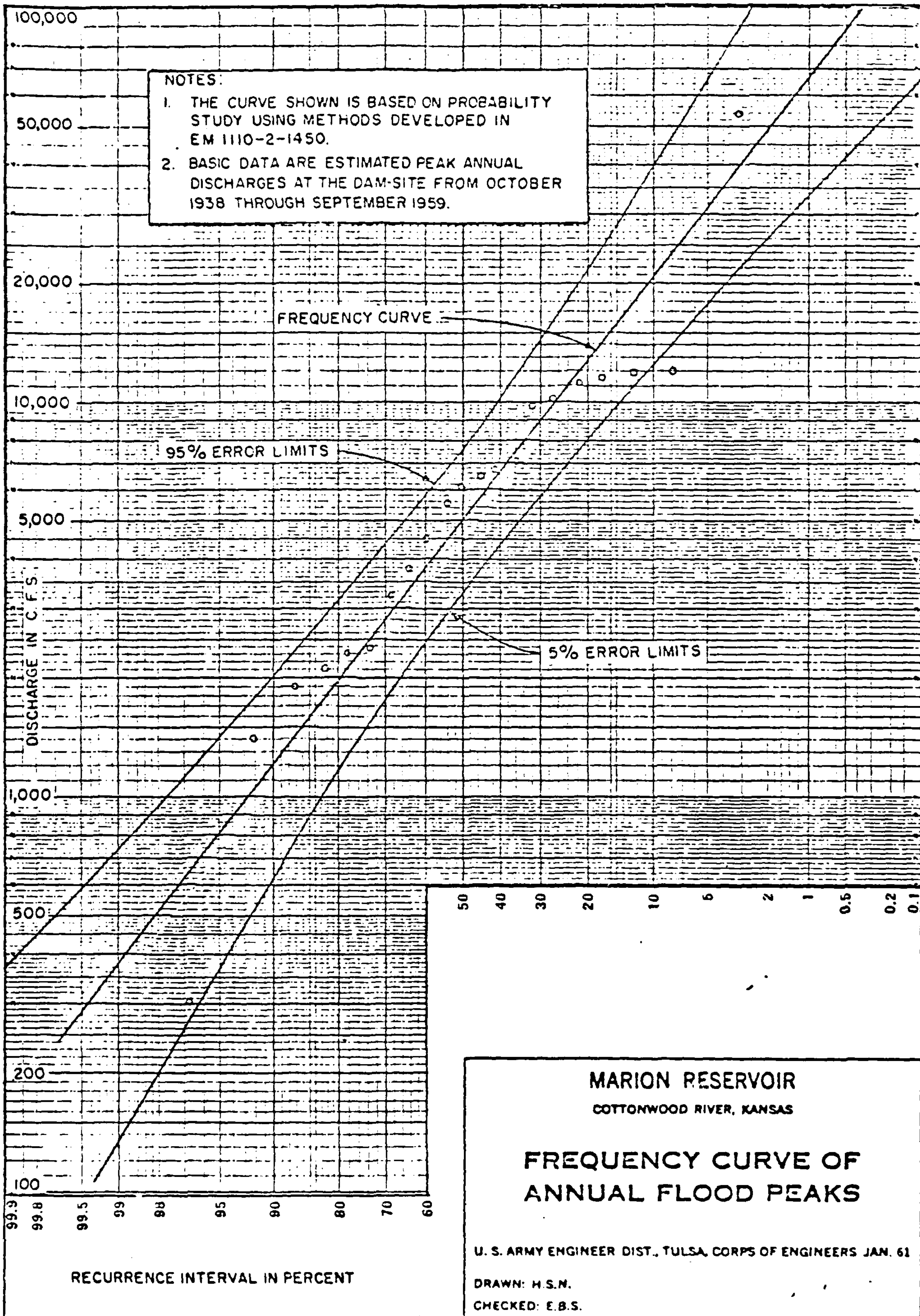
Top of Conservation (Power) Pool Elevation	1350.5
Top of Flood Control Pool Elevation	1358.5

WATER SUPPLY FACILITY

Low Flow	
Type	Pipe
Size	24" Dia.
Elevation	1310
Capacity at Conservation Pool (c.f.s.)	97
Static Head Pipe	
Diameter	24" Dia.
Elevation	1310

SPILLWAY

Type	Ogee
Crest Width	120'
Crest Elevation	1318.5
Control	3-40'x40' (Tainter Gates)
Capacity at Conservation Pool (c.f.s.)	81,000
Capacity at Flood Control Pool (c.f.s.)	113,000


NOTES:
1. THE CURVE SHOWN IS BASED ON PROBABILITY STUDY USING METHODS DEVELOPED IN EM 1110-2-1450.
2. BASIC DATA ARE ESTIMATED PEAK ANNUAL DISCHARGES AT THE DAM-SITE FROM OCTOBER 1938 THROUGH SEPTEMBER 1959.
100,000
50,000
20,000
10,000
5,000
1,000
500
200
100
DISCHARGE IN C.F.S.
FREQUENCY CURVE
95% ERROR LIMITS
5% ERROR LIMITS
99.9 99.8 99.5 99 98 95 90 80 70 60
50 40 30 20 10 5 2 1 0.5 0.2 0.1
RECURRENCE INTERVAL IN PERCENT
MARION RESERVOIR
COTTONWOOD RIVER, KANSAS
FREQUENCY CURVE OF ANNUAL FLOOD PEAKS
U. S. ARMY ENGINEER DIST., TULSA, CORPS OF ENGINEERS JAN. 61
DRAWN: H.S.N.
CHECKED: E.B.S.

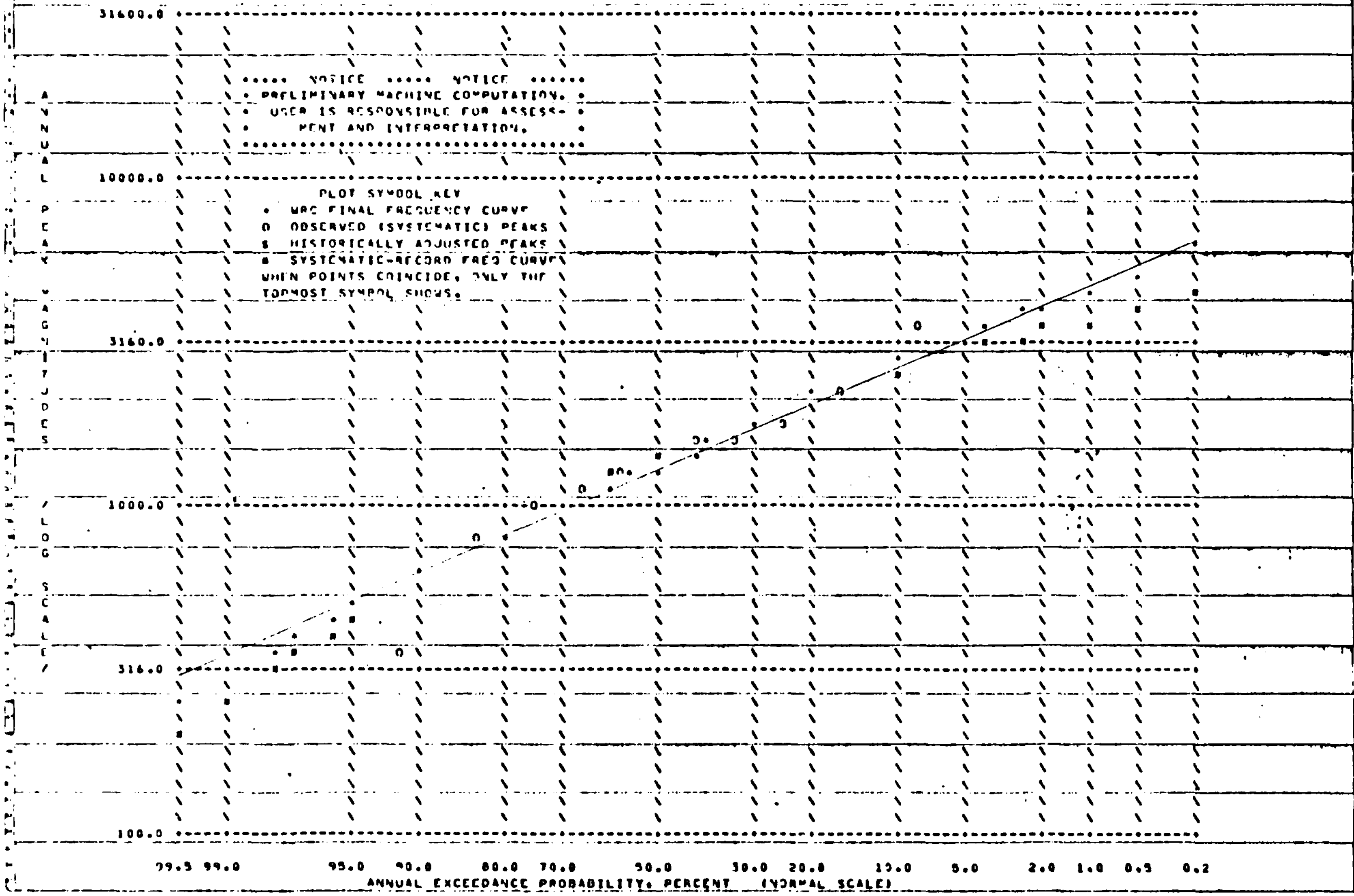
MARION

PGM J407 VER 3.4
(REV 10/22/79)

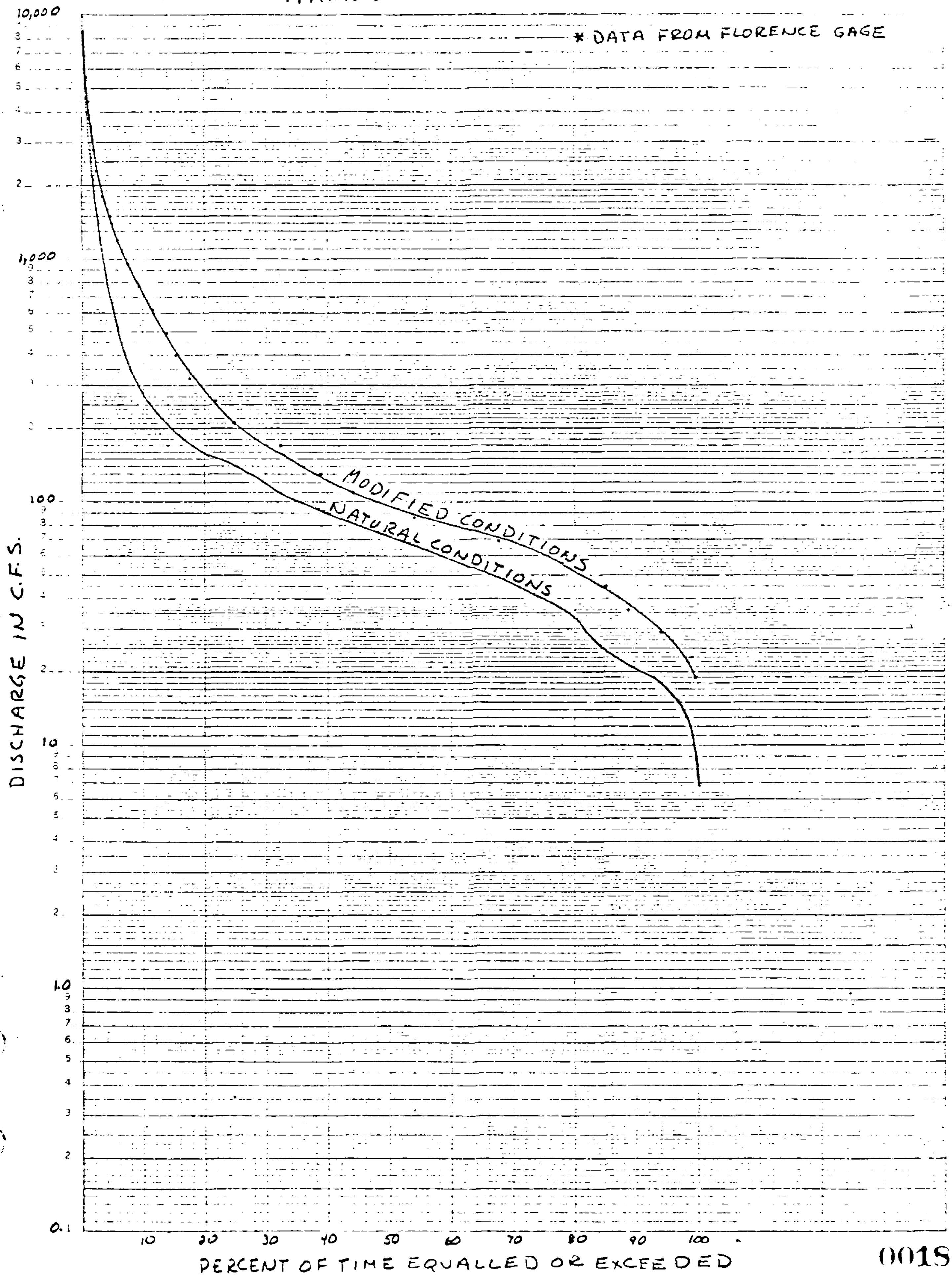
U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BUL. 17-A.

FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 3/80 AT 1538 SEQ 1.

STATION - 07179735/USGS COTTONWOOD R BL MARION LK, KS 1969-1979 07179795/USGS



MARION- COTTONWOOD R.



00180

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980
WQ DATA 0.5 MILES BELOW MARION

STN 1.SUMMARY.1

000
38 21 05.0 097 03 30.0 2
COTTONWOOD R NR MARION, KS
20115 KANSAS
100491

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

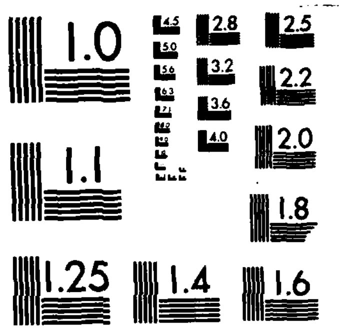
SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 68/02/07 TO 68/09/05

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	8	0	0	0	0	0	0	0	0	0
MEAN	17.63	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MEDIAN	15.00	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
NO OF VIOLS	1	0	0	0	0	0	0	0	0	0
PERCENT VIOL	13.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MINIMUM VIOL	34.00	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MEAN VIOL	34.00	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MAXIMUM VIOL	34.00	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

001S1

AD-A156 496 RESERVOIR CONTROL CENTER: ACTIVITIES AND ACCOMPLISHMENTS OF THE SOUTHWEST..(U) CORPS OF ENGINEERS DALLAS TX SOUTHWESTERN DIV JAN 81 3/6

UNCLASSIFIED F/G 13/2 NL


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 1.SUMMARY.2

WQ DATA 0.5 TO 5 MILES BELOW MARION

07180000
38 21 05.0 097 03 30.0 2
COTTONWOOD R NR MARION, KS
20115 KANSAS
100491

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 68/02/07 TO 68/09/05

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	0	0	0	0	8	8	0	0	0	0
MEAN	0.0	0.0	0.0	0.0	7.700	7.700	0.0	0.0	0.	0.0
MEDIAN	0.0	0.0	0.0	0.0	7.700	7.700	0.0	0.0	0.	0.0
NO OF VIOLS	0	0	0	0	0	0	0	0	0	0
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.0
MEAN VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	6.500	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	8.500	*********	10.000	50.00	5000.	50.00

STN 2.SUMMARY.1

TORET RETRIEVAL TE 80/10/22 - STAND - VERSION OF SEP. 1980
Q DATA 0.5 TO ES BELOW MARION

071
38 2 .0 097 05 00.0 2
COTTONWOOD R BL MARION LK, KS
20115 KANSAS
100491

TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 68/07/09 TO 79/06/05

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	92	0	0	0	0	0	0	0	0	0
MEAN	14.64	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MEDIAN	17.00	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
NO OF VIOLS	0	0	0	0	0	0	0	0	0	0
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MEAN VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

00183

DRET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 2.SUMMARY.2
DATA 0.5 TO 5 MILES BELOW MARION

07179795
38 22 00.0 097 05 00.0 2
COTTONWOOD R BL MARION LK, KS
20115 KANSAS
100491

/PA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 68/07/39 TO 79/06/05

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
OF VALUES	0	0	0	0	90	90	0	0	0	23
N	0.0	0.0	0.0	0.0	7.674	7.674	0.0	0.0	0.	23.96
IAN	0.0	0.0	0.0	0.0	7.700	7.700	0.0	0.0	0.	8.00
OF VIOLS	0	0	0	0	0	0	0	0	0	4
CENT VIOL	0.	0.	0.	0.	0.	0.	0.	0.	0.	17.
IMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	65.00
N VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	71.25
IMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	90.00
CRITERIA	....	....	....	....	....	6.500	....	....	....	....
CRITERIA	50.00	50.00	2.000	10.000	8.500	....	10.000	50.00	5000.	50.00

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 3.SUMMARY.1
WQ DATA 0.5 TO MILES BELOW MARION

0
38 55.0 097 04 39.0 5
COTTONWOOD R.BELOW MARION DAM
20115 KANSAS
ARKANSAS
NEOSHO UNIT
/TYPA/AMBNT/STREAM
21KAN001 760326
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 75/11/11 TO 80/01/22

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	44	44	0	0	0	0	0	44	0	0
MEAN	12.61	0.213	0.0	0.	0.0	0.0	0.	9.250	0.0	0.0
MEDIAN	12.50	0.160	0.0	0.	0.0	0.0	0.	8.850	0.0	0.0
NO OF VIOLS	0	3	0	0	0	0	0	0	0	0
PERCENT VIOL	0.	7.	0.	0.	0.	0.	0.	0.	0.	0.
MINIMUM VIOL	0.0	0.530	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MEAN VIOL	0.0	0.577	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MAXIMUM VIOL	0.0	0.640	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 3.SUMMARY.2
NO DATA 0.5 TO 5 MILES BELOW MARION

000095
38 21 55.0 097 04 38.0 5
COTTONWOOD R.BELOW MARION DAM
20115 KANSAS
ARKANSAS
NEOSHO UNIT
21KAN001 760326
0000 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 75/11/11 TO 80/01/22

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00073 TURB JKSN JTU
NO OF VALUES	0	0	6	0	0	0	0	0	0	0
MEAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.0
MEDIAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.0
NO OF VIOLS	0	0	0	0	0	0	0	0	0	0
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.0
MEAN VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	6.500	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	8.500	*********	10.000	50.00	5000.	50.00

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 4.SUMMARY.1
W3 DATA 0.5 T[illegible] MILES BELOW MARION

0 1 CD-21
38 [illegible]1.0 097 01 43.0 5
COT.ONWOOD R BELOW MARION RES.
20115 KANSAS
ARKANSAS 100420
NEOSHO BASIN
/TYPA/AMBNT/STREAM 21KAN001 790818
0999 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 72/10/11 TO 76/04/27

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	14	0	0	0	0	0	0	14	0	0
MEAN	14.86	0.0	0.0	0.	0.0	0.0	0.	7.057	0.0	0.0
MEDIAN	13.50	0.0	0.0	0.	0.0	0.0	0.	7.300	0.0	0.0
NO OF VIOLS	0	0	0	0	0	0	0	2	0	0
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	14.	0.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	3.500	0.0	0.0
MEAN VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	4.100	0.0	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	4.700	0.0	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 4.SUMMARY.2
WQ DATA 0.5 TO 5 MILES BELOW MARION

002711 CO-21
38 20 41.0 097 01 43.0 5
COTTONWOOD R BELOW MARION RES.
20115 KANSAS
ARKANSAS 100420
NEOSHO BASIN
21KAN001 790818
0999 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 72/10/11 TO 76/04/27

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	0	0	0	0	0	0	0	0	0	14
MEAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	178.96
MEDIAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	67.50
NO OF VIOLS	0	0	0	0	0	0	0	0	0	8
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	0.	0.	57.
MINIMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	65.00
MEAN VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	306.25
MAXIMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	1100.00
MIN CRITERIA	....	....	....	....	....	6.500	....	....	....	....
MAX CRITERIA	50.00	50.00	2.000	10.000	8.500	....	10.000	50.00	5000.	50.00

00188

1. Project Name: John Redmond Dam and Reservoir

2. Project Location: River mile 343.7 on Grand (Neosho) River tributary to Arkansas River. Project watershed (3,015 square miles) located in Kansas; downstream management control stations located in Kansas and Oklahoma.

3. Type of Project:

a. General Category: Multiple-purpose storage reservoir (excluding hydropower).

b. Storage Allocations:

	Elevation Feet (N.G.V.D.)	Storage Acre-Feet	Storage Inches Runoff
Top Flood Control Pool	1068.0	630,250	3.91
Top Conservation Pool	1039.0	71,285	.44
Bottom Conservation Pool	1020.0	505	--
Water Supply Storage (24.5 mgd)		34,900	
Water Quality Storage (19.38 mgd)		27,600	

4. Water Management Criteria:

a. Authorized Project Purpose: Flood control, water supply, water quality, and recreation.

b. Water Use Contracts: Water storage - (1) - 24.5 mgd.

c. Interagency Agreements: The State of Kansas contracts for all the water supply storage available. Agreement with Kansas State Fish & Wildlife Department for pool level manipulation.

d. Informal Commitments: None.

e. System Regulation Objectives: Regulated in a system with Council Grove and Marion where releases from the system can only be made from John Redmond. Operated to retain equivalent flood control capabilities insofar as possible.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(b) Quantity: The lake provides storage for flow augmentation in times of drought.

(2) Negative Effects:

(a) Quality: Due to the basin morphometry, John Redmond Lake stratifies only occasionally. Such weak and ephemeral stratification is not associated with water quality degradation.

(b) Quantity: The lake is operated under a water level management plan aimed at enhancing the fishery. This can cause tailwater fluctuations to be greater than normal.

b. Project Effect on Instream Flows:

(1) General: Discharge duration curves for the natural and modified conditions are attached. The frequency curve for post-impoundment is available.

(2) Negative Effects: Historical data from John Redmond tailwater stations were compared to Kansas Class A water quality standards (See Attachments). No significant violations of these standards were found, however, no data were available for many parameters.

c. Project Effects on System Regulation: The project has a significant flood controlling and flow augmenting effect on the Grand River system in Kansas.

7. Alternatives:

a. Reservoir Regulation: None.

b. Structural Modification: None.

c. Storage Reallocation: None.

d. Other: No action.

8. Action Taken to Date: None.

9. Planned Action: None.

JOHN REDMOND
GRAND (NEOSHO) RIVER, KANSAS

Top of Conservation (Power) Pool Elevation	1039
Top of Flood Control Pool Elevation	1068

WATER SUPPLY FACILITY

Low Flow	
Type	Pipe
Size	2-24" Dia.
Elevation	1015.5
Capacity at Conservation Pool (c.f.s.)	151
Static Head Pipe	
Diameter	30" Dia.
Elevation	1015.5

SPILLWAY

Type	Ogee
Crest Width	560'
Crest Elevation	1033
Control	14-40'x35' (Tainter Gates)
Capacity at Conservation Pool (c.f.s.)	250000
Capacity at Flood Control Pool (c.f.s.)	428,000

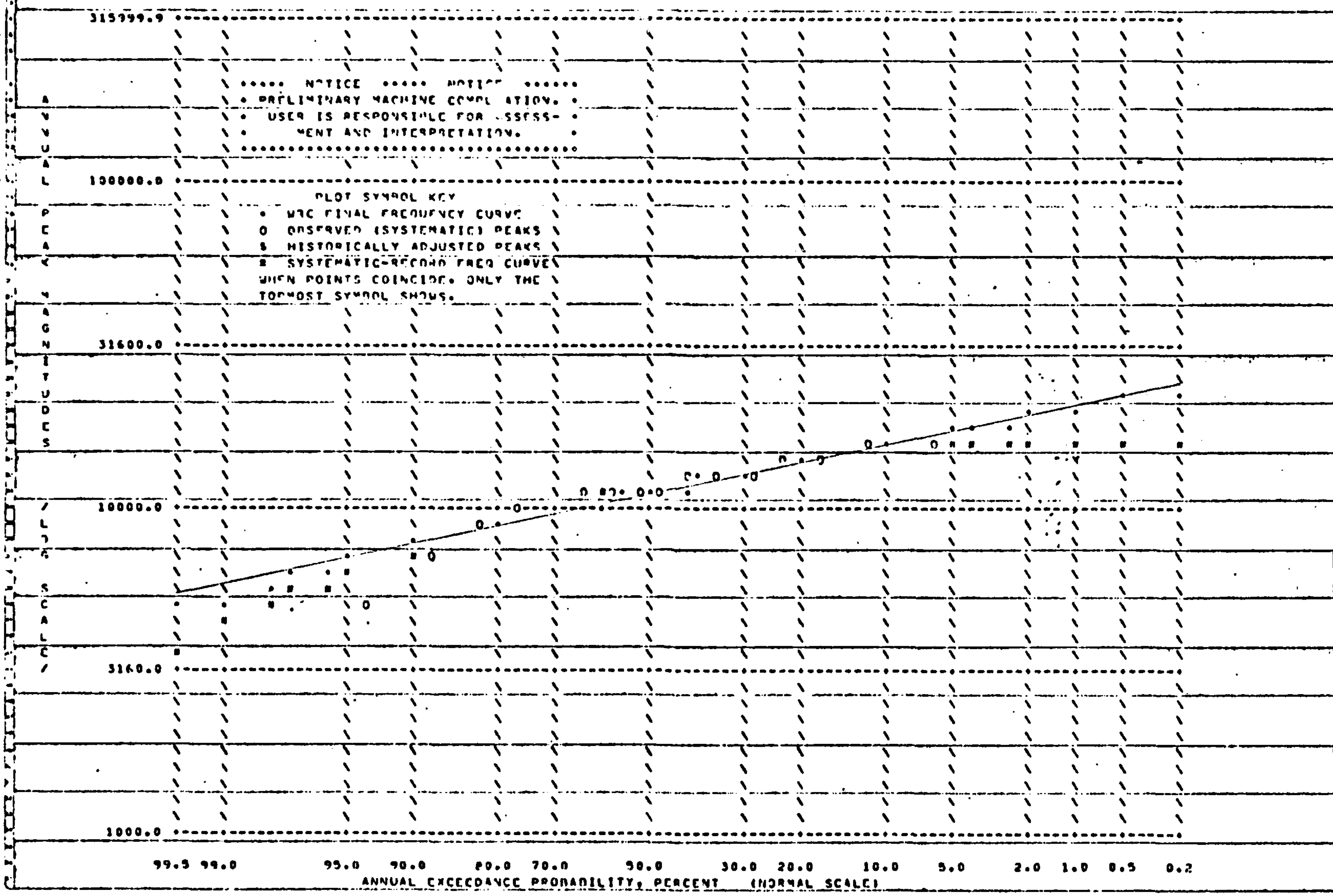
MODIFIED JOHN REDMOND

PGM J407 VER 3.4
(REV 10/22/79)

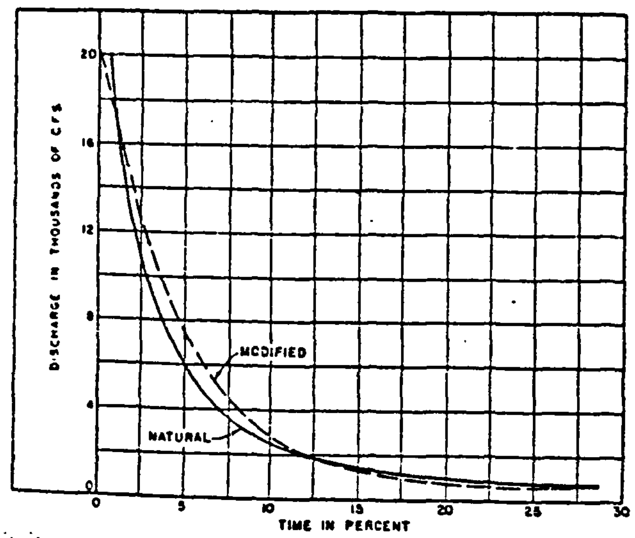
U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 3/80 AT 1522 SEQ 1.0001

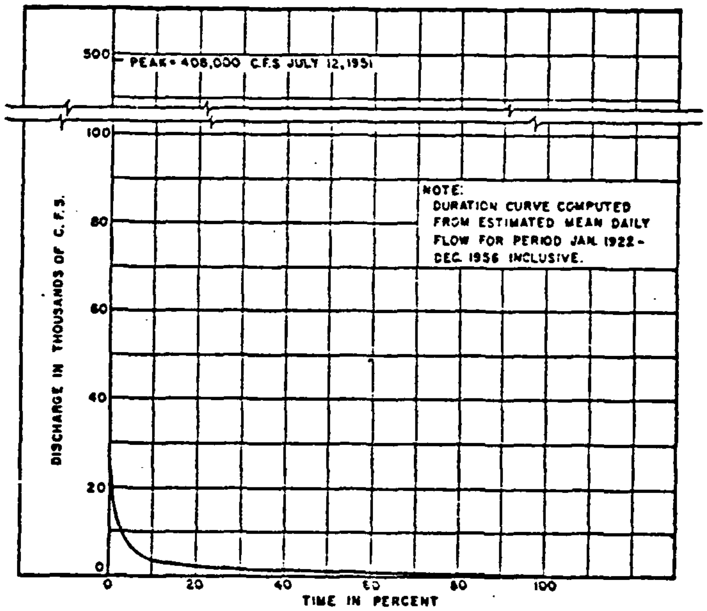
STATION - 07182510/USGS NEOSHO R AT BURLINGTON, KS 1964-1979 07182510/USGS



00192



EXPANDED FLOW DURATION CURVES



FLOW DURATION CURVE

DATE	NO.	DESCRIPTION	CHK'D	REC	APPR.

REVISIONS

U.S. ARMY ENGINEER DISTRICT, SAVANNAH
CORPS OF ENGINEERS
SAVANNAH, GEORGIA

U.S. ARMY ENGINEER DISTRICT, TULSA
CORPS OF ENGINEERS
TULSA, OKLAHOMA

DSGN. CHKD. ARKANSAS RIVER WATERSHED GRAND (NEOSHO) RIVER KANSAS

COORD.

ACT CHIEF DESIGN BRANCH

APPROVED.
ACT CHIEF, ENGINEERING DIV

APPROVED
COL., SAV. DIST. ENGR.

JOHN REDMOND DAM
SPILLWAY AND
COMPLETION OF EMBANKMENT
STAGE
DISCHARGE HYDROGRAPHS

RECOMMENDED.
CHIEF, DESIGN BRANCH "S"

DATE: OCTOBER 12, 1960

SCALE: AS SHOWN

RECOMMENDED:
M. W. Paul
CHIEF, ENGINEERING DIVISION

TO ACCOMPANY SPECIFICATIONS ISSUED UNDER INVITATION NO CIVENG 34-066-61-53

APPROVED.
COL. C.E. DISTRICT ENGINEER - TULSA DISTRICT

DRAWING NUMBER
C152-603
SHEET 3 OF 120 SHEETS

(3)

00193

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980
WQ DATA 4 MILES BELOW JOHN REDMOND

STN 1.SUMMARY.1

07182510
38 11 40.0 095 44 10.0 2
NEOSHO R AT BURLINGTON, KS
20031 KANSAS
100491

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 64/01/05 TO 75/07/21

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	72	0	0	0	0	0	0	0	0	0
MEAN	13.49	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MEDIAN	13.39	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
NO OF VIOLS	0	0	0	0	0	0	0	0	0	0
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MEAN VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

STORET R[illegible]VAL DATE 80/10/22 - STAND - VERSION OF SEP. 19[illegible] STN 1.SUMMARY.2
WQ DATA 4[illegible] LES BELOW JOHN REDMOND

07182510
38 11 40.0 095 44 10.0 2
NEOSHO R AT BURLINGTON, KS
20031 KANSAS
100491

/TYPA/AMBNT/STREAM
112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 64/01/06 TO 75/07/21

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	0	0	0	0	85	85	0	0	0	13
MEAN	0.0	0.0	0.0	0.0	7.752	7.752	0.0	0.0	0.	106.69
MEDIAN	0.0	0.0	0.0	0.0	7.700	7.700	0.0	0.0	0.	110.00
NO OF VIOLS	0	0	0	0	0	0	0	0	0	10
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	0.	0.	77.
MINIMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	55.00
MEAN VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	133.50
MAXIMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	350.00
MIN CRITERIA	*********	*********	*********	*********	*********	6.500	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	8.500	*********	10.000	50.00	5000.	50.00

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STV 2.SUMMARY.1

NO DATA 4 MILES BELOW JOHN REDMOND

000272 KAN046
38 11 40.0 095 44 10.0 3
NEOSHO R. AT BURLINGTON, KS.
20031 KANSAS
ARKANSAS R. BASIN. 100491
NEOSHO UNIT.
21KAN001
0000 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 74/01/22 TO 80/03/04

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	62	63	0	0	0	0	0	62	0	0
MEAN	13.76	0.274	0.0	0.	0.0	0.0	0.	9.903	0.0	0.0
MEDIAN	15.50	0.220	0.0	0.	0.0	0.0	0.	9.100	0.0	0.0
NO OF VIOLS	0	9	0	0	0	0	0	1	0	0
PERCENT VIOL	0.	14.	0.	0.	0.	0.	0.	2.	0.	0.
MINIMUM VIOL	0.0	0.510	0.0	0.	0.0	0.0	0.	4.800	0.0	0.0
MEAN VIOL	0.0	0.673	0.0	0.	0.0	0.0	0.	4.800	0.0	0.0
MAXIMUM VIOL	0.0	1.100	0.0	0.	0.0	0.0	0.	4.800	0.0	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

00196

STORET RETRIEV... DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 2.SUMMARY.2
WQ DATA 4 MI... BELOW JOHN REDMOND

38 ... 40.0 095 44 10.0 3 KAN046
NEOSHO R. AT BURLINGTON, KS.
20031 KANSAS
ARKANSAS R. BASIN. 100491
NEOSHO UNIT.
21KAN001
0000 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 74/01/22 TO 80/03/04

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	0	0	8	0	0	0	0	0	0	16
MEAN	0.0	0.0	0.500	0.0	0.0	0.0	0.0	0.0	0.	74.05
MEDIAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	70.00
NO OF VIOLS	0	0	1	0	0	0	0	0	0	12
PERCENT VIOL	0.	0.	13.	0.	0.	0.	0.	0.	0.	75.
MINIMUM VIOL	0.0	0.0	4.000	0.0	0.0	0.0	0.0	0.0	0.	65.00
MEAN VIOL	0.0	0.0	4.000	0.0	0.0	0.0	0.0	0.0	0.	87.08
MAXIMUM VIOL	0.0	0.0	4.000	0.0	0.0	0.0	0.0	0.0	0.	130.00
MIN CRITERIA	....	....	....	....	....	6.500	....	....	....	....
MAX CRITERIA	50.00	50.00	2.000	10.000	8.500	....	10.000	50.00	5000.	50.00

1. Project Name: Fort Gibson Lake

2. Project Location: River mile 7.7 on Grand (Neosho) River tributary to Arkansas River. Project watershed (12,492 square miles) located in Oklahoma; downstream management control stations located in Arkansas.

3. Type of Project:

a. General category: Multiple-purpose storage reservoir (including hydropower).

b. Storage allocations:

	Elevation (feet) (N.G.V.D.)	Storage Acre-feet	Storage Inches Runoff
Top Flood Control Pool	582.0	1,284,400	1.93
Top Conservation Pool	554.0	365,200	.55
Bottom Conservation Pool	551.0	311,300	.47

c. Hydropower category: peak demand

4. Water Management Criteria:

a. Authorized project purposes: *flood control* and hydropower

b. Water use contracts: Grand River Dam Authority has several - - Corps has no contracts.

c. Interagency agreements: Southwestern Power Administration markets the produced power.

d. Informal commitments: none

e. System regulation objectives: Regulated in the system to maximize power generation and to control floods while retaining equivalent flood control capabilities with other projects in the system insofar as possible. Also operated as a run-of-the-river mini-system with Pensacola and Hudson for power generation.

5. Project Evaluation:

a. Effects of impoundment on water stored:

(1) Positive effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(b) Quantity: The lake provides storage for flow augmentation in times of drought.

(2) Negative effects:

(a) Quality: Fort Gibson Lake becomes thermally stratified from early summer through mid-fall. Chemical reactions within the anoxic hypolimnion cause an increase in dissolved iron and manganese within this zone. The water in the hypolimnion decreases in pH and temperature while amnonia and hydrogen sulfide levels are elevated. When the lake returns to complete mixing in the fall, the water quality becomes more desirable.

(b) Quantity: Power generation causes tailwater fluctuations to be greater than normal.

(3) Cause of negative effects: Soils within the watershed are high in iron and manganese. Agricultural operations lead to large input of these soils to the lake.

6. <u>Project Effect on Instream Flows</u>:

(1) General: Discharge frequency and duration curves for the modified condition are attached. No records prior to impoundment were available for analysis. The project is being studied for possible additional hydropower units.

(2) Positive effects: not known

(3) Negative effects: Historical data from Fort Gibson tailwater stations were compared to Oklahoma Raw Water Supply Standards (see attachments). These drinking water standards were used because Oklahoma has few numerical standards for other water classes. Violations of iron, manganese, lead, and cadmium standards were common. Few violations of other parameters occurred.

(4) Cause of negative effects: Iron, manganese, and lead were common constituents of the watershed soils. Chemical cycling within the hypolimnion increases levels of these metals within the discharge. The cause of elevated cadmium levels is unknown.

(5) Project effects on System regulation: The project has a significant impact on the flood control capability of the Grand River and the Arkansas River navigation project.

7. <u>Constraints on Obtaining Instream Quantity and Quality Objectives</u>: Selective water level withdrawals for downstream releases is not provided. The flood control and power releases are determined by and limited to the requirements specified by the navigation taper needs.

8. <u>Alternatives</u>:

a. <u>Reservoir regulation</u>: None

b. Structural modification: Selective withdrawal system would improve the quality of releases.

c. Storage reallocation: none

d. Other: no action

9. Action Taken to Date: none

10. Planned action: none

FORT GIBSON
GRAND (NEOSHO) RIVER, OKLAHOMA

Top of Conservation (Power) Pool Elevation	554.0 (Power)
Top of Flood Control Pool Elevation	582.0

OUTLET WORKS

Type	Sluice	Penstock
Size	10-5.67'x7'	4-18' Dia.
Intake Elevation	502.0	511.5
Control Gates	10-5.67'x7'	
Capacity at Conservation Pool (c.f.s.)	16,900	
Capacity at Flood Control Pool (c.f.s.)	21,000	

WATER SUPPLY FACILITY

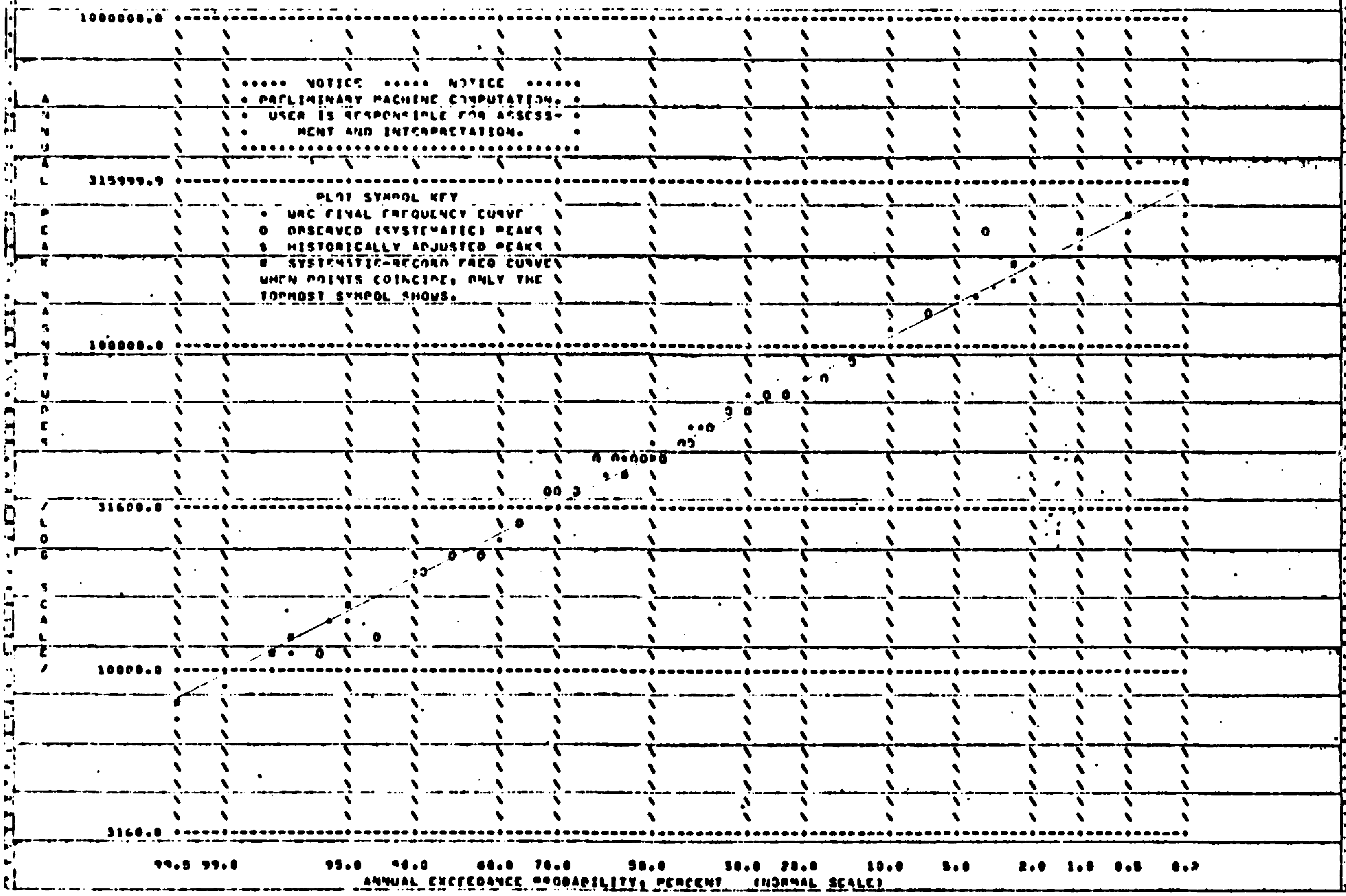
Static Head Pipe	
Diameter	48" Dia.
Elevation	535.0

SPILLWAY

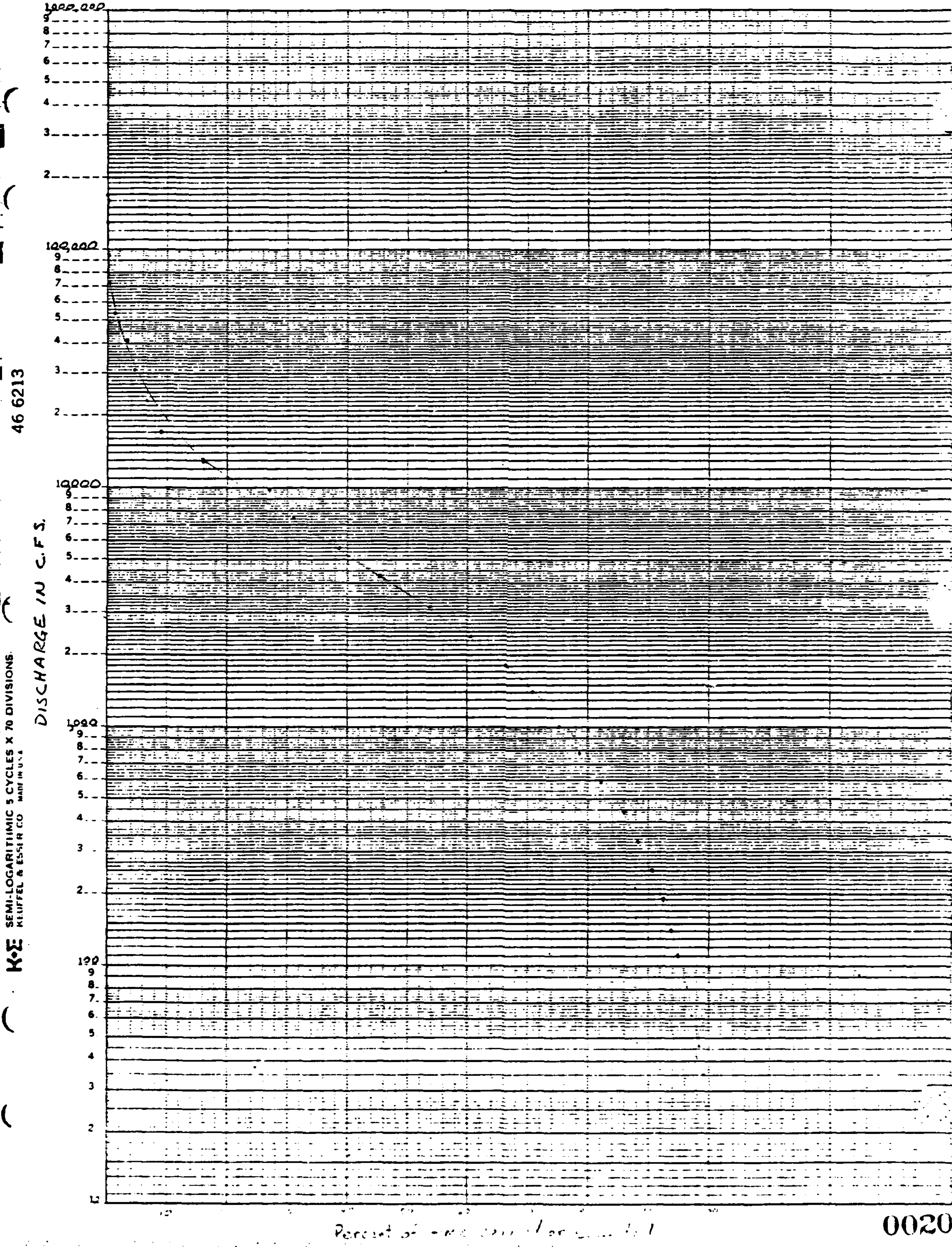
Type	Ogee
Crest Width	1200'
Crest Elevation	547.0
Control	30-40'x35' (Tainter Gates)
Capacity at Conservation Pool (c.f.s.)	67,500
Capacity at Flood Control Pool (c.f.s.)	986,000

PGM J407 VER 3.4 U. S. GEOLOGICAL SURVEY
(REV 10/22/79) ANNUAL PEAK FLOW FREQUENCY ANALYSIS FREQUENCY STUDY OF ANNUAL PEAKS
FOLLOWING WRC GUIDELINES BULL. 17-A. RUN-DATE 11/ 3/80 AT 1504 SEQ 1

STATION - 07193500/USGS NEOSHO RIVER BLW FT GIBSON LAKE NR FT GIBSON, OK 1953-1977 07193500/USGS



FT. GIBSON - Neosho R. below Ft. Gibson Lake



00203

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 1.SUMMARY.1
NO DATA 1 MILE BELOW FT. GIBSON

0 00
35 15.0 095 13 45.0 2
NEOSHO RIVER BLW FT GIBSON LAKE NR FT GIBSON, OK
40021 OKLAHOMA CHEROKEE
101492

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 53/09/30 TO 80/07/06

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	237	35	27	11	23	37	23	109	0	8
MEAN	15.69	0.131	1.44	127.	7.261	4.05	10.	9.774	0.0	258.7
MEDIAN	15.50	0.070	1.00	100.	10.000	0.00	10.	9.500	0.0	245.0
NO OF VIOLS	0	1	0	0	2	0	0	4	0	3
PERCENT VIOL	0.	3.	0.	0.	9.	0.	0.	4.	0.	38.
MINIMUM VIOL	0.0	1.000	0.0	0.	21.000	0.0	0.	3.600	0.0	310.0
MEAN VIOL	0.0	1.000	0.0	0.	22.000	0.0	0.	4.200	0.0	373.3
MAXIMUM VIOL	0.0	1.000	0.0	0.	23.000	0.0	0.	4.500	0.0	470.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

00204

ORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 1.SUMMARY.2
DATA 1 MILE BELOW FT. GIBSON

07193500
35 51 15.0 095 13 45.0 2
NEOSHO RIVER BLW FT GIBSON LAKE NR FT GIBSON, OK
40021 OKLAHOMA CHEROKEE
101492

YPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 53/09/30 TO 80/07/08

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
OF VALUES	23	22	22	0	360	360	23	22	24	60
AN	58.52	58.50	0.105	0.0	7.775	7.775	0.565	0.55	72.	14.63
DIAN	65.00	50.00	0.100	0.0	7.800	7.800	0.0	0.0	30.	10.00
OF VIOLS	12	9	0	0	0	4	0	0	0	1
RCENT VIOL	52.	41.	0.	0.	0.	1.	0.	0.	0.	2.
NIMUM VIOL	65.00	57.00	0.0	0.0	0.0	6.200	0.0	0.0	0.	140.00
AN VIOL	94.17	83.00	0.0	0.0	0.0	6.275	0.0	0.0	0.	140.00
XIMUM VIOL	100.00	120.00	0.0	0.0	0.0	6.400	0.0	0.0	0.	140.00
N CRITERIA	*********	*********	*********	*********	*********	6.500	*********	*********	*********	*********
X CRITERIA	50.00	50.00	2.000	10.000	9.000	*********	10.000	50.00	5000.	50.00

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980

HQ DATA 1 MIL BELOW FT. GIBSON

STN 2.SUMMARY.1

2 131X282216 07193500

35 45.0 095 13 45.0 2

NEOSHO RIVER NEAR FT. GIBSON

40021 OKLAHOMA

ARKANSAS RIVER 1004

NEOSHO RIVER

210KOSHD

0000 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 59/10/01 TO 77/09/20

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	18	0	0	0	0	0	0	30	0	0
MEAN	16.14	0.0	0.0	0.	0.0	0.0	0.	10.048	0.0	0.0
MEDIAN	17.00	0.0	0.0	0.	0.0	0.0	0.	11.445	0.0	0.0
NO OF VIOLS	0	0	0	0	0	0	0	1	0	0
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	3.	0.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	4.500	0.0	0.0
MEAN VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	4.500	0.0	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	4.500	0.0	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STV 2.SUMMARY.2

NO DATA 1 MILE BELOW FT. GIBSON

21600F31X282216 07193500
35 51 15.0 095 13 45.0 2
NEOSHO RIVER NEAR FT. GIBSON
40021 OKLAHOMA
ARKANSAS RIVER 1004
NEOSHO RIVER
210KOSHD
0000 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 59/10/01 TO 77/09/20

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	0	0	0	0	191	191	0	8	0	0
MEAN	0.0	0.0	0.0	0.0	7.840	7.840	0.0	1.38	0.	0.0
MEDIAN	0.0	0.0	0.0	0.0	7.899	7.899	0.0	1.00	0.	0.0
NO OF VIOLS	0	0	0	0	0	1	0	0	0	0
PERCENT VIOL	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.0	0.0	6.199	0.0	0.0	0.	0.0
MEAN VIOL	0.0	0.0	0.0	0.0	0.0	6.199	0.0	0.0	0.	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.0	0.0	6.199	0.0	0.0	0.	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	6.500	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	9.000	*********	10.000	50.00	5000.	50.00

1. Project Name: Webbers Falls Lock and Dam

2. Project Location: River Mile 368.9 on Arkansas River. Project watershed (97,033 square miles) located in Oklahoma.

3. Type of Project:

a. General Category: Navigation (including hydropower).

b. Storage Allocations:

	Elevation Feet (N.G.V.D.)	Storage Acre-Feet	Storage Inches Runoff
Top Upper Pool	490.0	165,200	
Top Power Pondage	490.0-487.0	30,000	

c. Hydropower Category: Run-of-river

4. Water Management Criteria:

a. Authorized Project Purpose: Navigation and hydropower

b. Water Use Contracts: None

c. Interagency Agreements: SPA markets power

d. Informal Commitments: None

e. System Regulation Objectives: The project is basically run-of-river project that has only minor regulating abilities.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored: No significant effects are caused by this type of impoundment on the quality of the water.

b. Effects on Instream Flows: No significant effects are caused by this type of impoundment on the quality or quantity of flows.

c. Project Effects on System Regulation: The project provides for navigation on the Arkansas River system.

6. Alternatives:

a. Reservoir Regulation: None

b. Structural Modification: None

c. Storage Reallocation: None

d. Other: No action

7. Action Taken To Date: None

8. Planned Action: None

1. Project Name: Tenkiller Ferry Lake

2. Project Location: River mile 12.8 on Illinois River tributary to Arkansas River. Project watershed (1,610 square miles) located in Oklahoma; downstream management control stations location in Oklahoma and Arkansas.

3. Type of Project:

a. General Category: Multiple-purpose storage reservoir (including hydro-power).

b. Storage allocations:

	Elevation (feet) (N.G.V.D.)	Storage Acre-feet	Inches Runoff
Top Flood Control Pool	667.0	1,230,800	14.33
Top Conservation Pool	632.0	654,100	7.62
Bottom Conservation Pool	594.5	283,100	
Water Supply Storage (16 mgd)		25,400	

c. Hydropower category: Peak demand

4. Water Management Criteria:

a. Authorized project purpose: flood control and hydropower.

b. Water use contracts: Existing water storage - (7) - 11.1 mgd; pending water storage - (1) - 0.1 mgd; and water withdrawal - (25) - 1.0 mgd.

c. Interagency agreement:

(1) Fish and Wildlife Department agreement to make daily releases to accomodate downstream trout fishery.

(2) Southwestern Power Administration market power.

d. Informal commitment: Agreement with SPA to make a daily power release for trout fishery rather than making low flow releases through outlet works.

e. System regulation objectives: The project is regulated in the system to maximize power generation and to control floods while retaining equivalent flood control capabilities with other projects in the system.

5. Project Evaluation:

a. Effects of impoundment on water stored:

(1) Positive effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(b) Quantity: The lake provides storage for flow augmentation in time of drought.

(3) Cause of negative effects: Soils within the watershed are high in iron and manganese. Agricultural operations lead to input of these soils to the lake.

6. Project effect on instream flows:

(1) General: Discharge frequency and duration curves for the natural and modified conditions are attached. The project is being studied for possible additional hydropower units.

(2) Positive effects: Reductions of peak flow magnitudes have been noted since impoundment.

(3) Negative effects: Historical data from Tenkiller tailwater stations were compared to Oklahoma Raw Water Supply Standards (See Attachments). These drinking water standards were used because Oklahoma has few numerical standards for other water classes. Problem areas were found in dissolved oxygen levels and temperature. Approximately 20 percent of the samples were less than 6 ppm dissolved oxygen and 10 percent violated the 20° C temperature standard. These two values are set to protect a trout fishery in the river.

(4) Cause of negative effects: Water withdrawn from the hypolimnion for power generation is anoxic. Turbulence from the release is insufficient to allow this water to meet State standards for DO even 3 to 5 miles below the dam. When the lake is not stratified, the water in this reach exceeds temperature requirements.

(5) Project effects on system regulation: The project has a significant impact on flood control and navigation on the Arkansas River system.

7. Constraints on Obtaining Instream Quantity and Quality Objectives: Unable to make selective water level withdrawals for down releases. The flood control and power releases are determined by and limited to the requirements specified by the navigation taper needs.

8. Alternatives:

a. Reservoir regulation: none

b. Structural modification: A selective withdrawal facility may permit a suitable mixture of water for the downstream trout fishery. A computer similation would be required to substantiate this alternative.

c. Storage reallocation: none

d. Other: Oxygen injection could improve the downstream fishery.

e. No action:

9. Action Taken to Date: none

10. Planned action: none

TENKILLER
ILLINOIS RIVER, OKLAHOMA

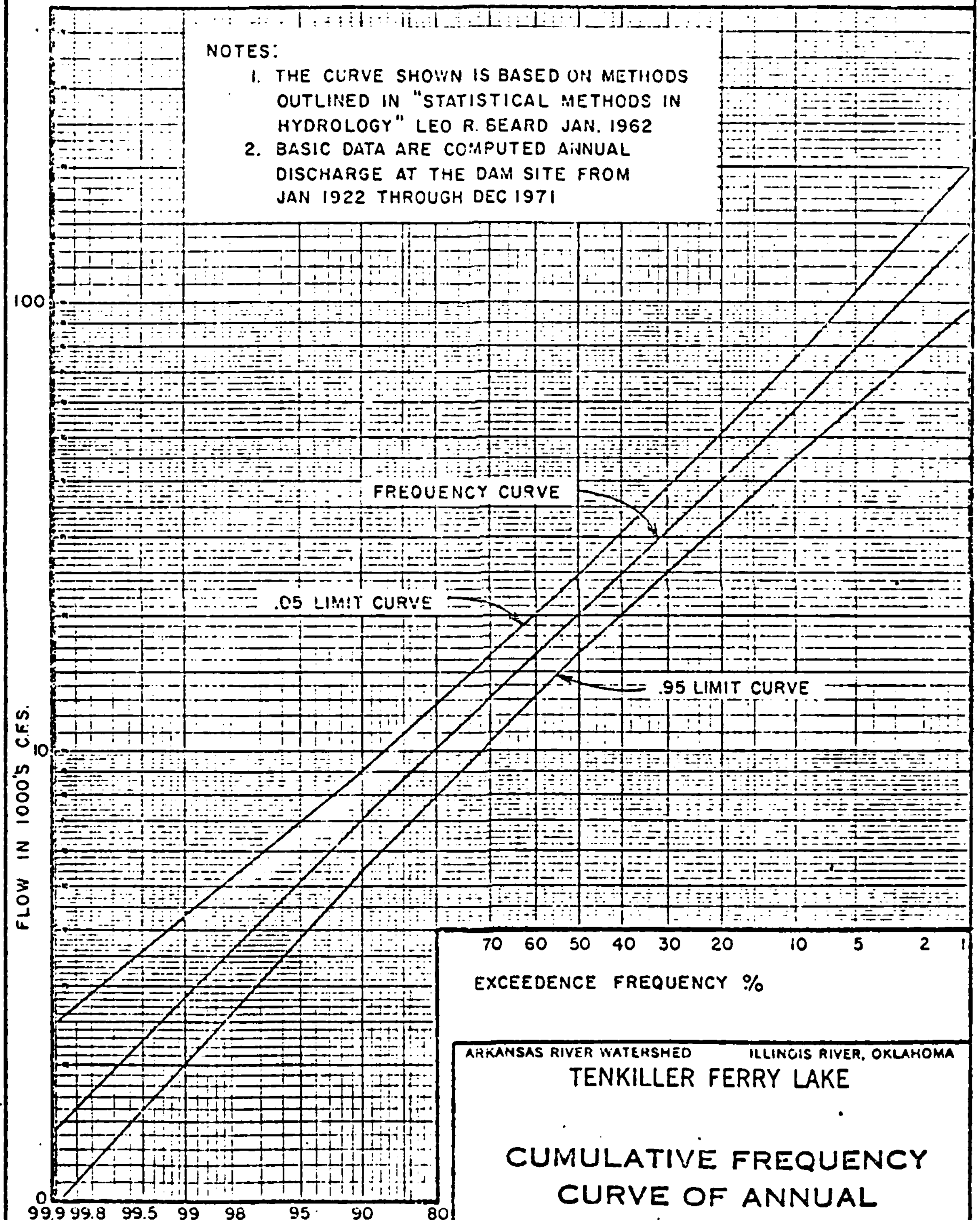
Top of Conservation (Power) Pool Elevation	632.0 (Power)
Top of Flood Control Pool Elevation	667.0

OUTLET WORKS

Type	Conduit	Penstock
Size	19' Dia.	19' Dia.
Intake Elevation	500.0	500.0
Control Gates	2-9'x19'	
Capacity at Conservation Pool (c.f.s.)	20,800	
Capacity at Flood Control Pool (c.f.s.)	23,200	

SPILLWAY

Type	Chute
Crest Width	500'
Crest Elevation	642.0
Control	10-50'x25' (Tainter Gates)
Capacity at Conservation Pool (c.f.s.)	0
Capacity at Flood Control Pool (c.f.s.)	218,000



ARKANSAS RIVER WATERSHED ILLINOIS RIVER, OKLAHOMA

TENKILLER FERRY LAKE

CUMULATIVE FREQUENCY CURVE OF ANNUAL PEAK FLOWS

NATURAL CONDITIONS

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS SEPT 72
DRAWN: W.J.T.
CHECKED: N.A.F.

00214

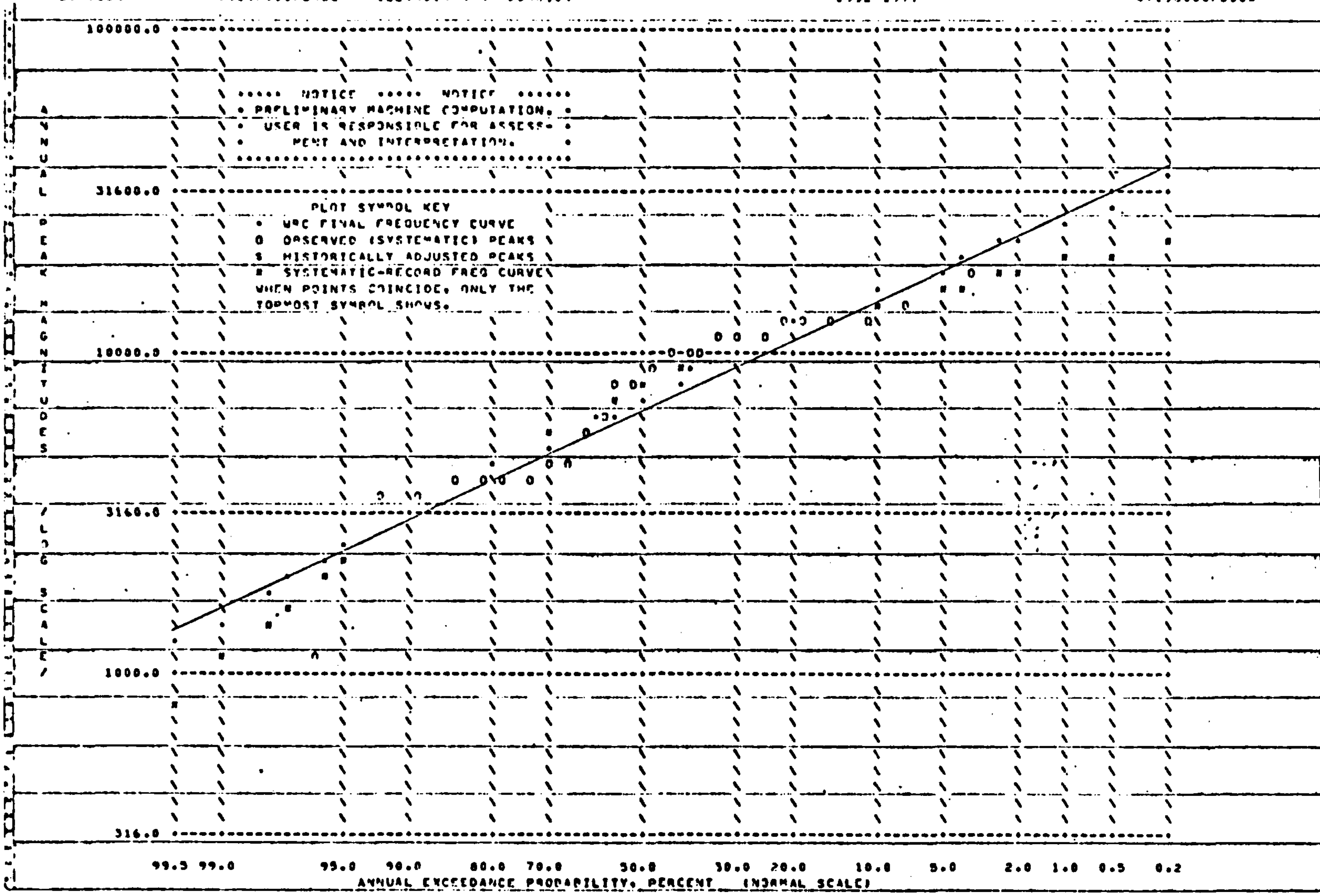
MODIFIED TENKILLER

PGM J407 VER 3.4
(REV 10/22/79)

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

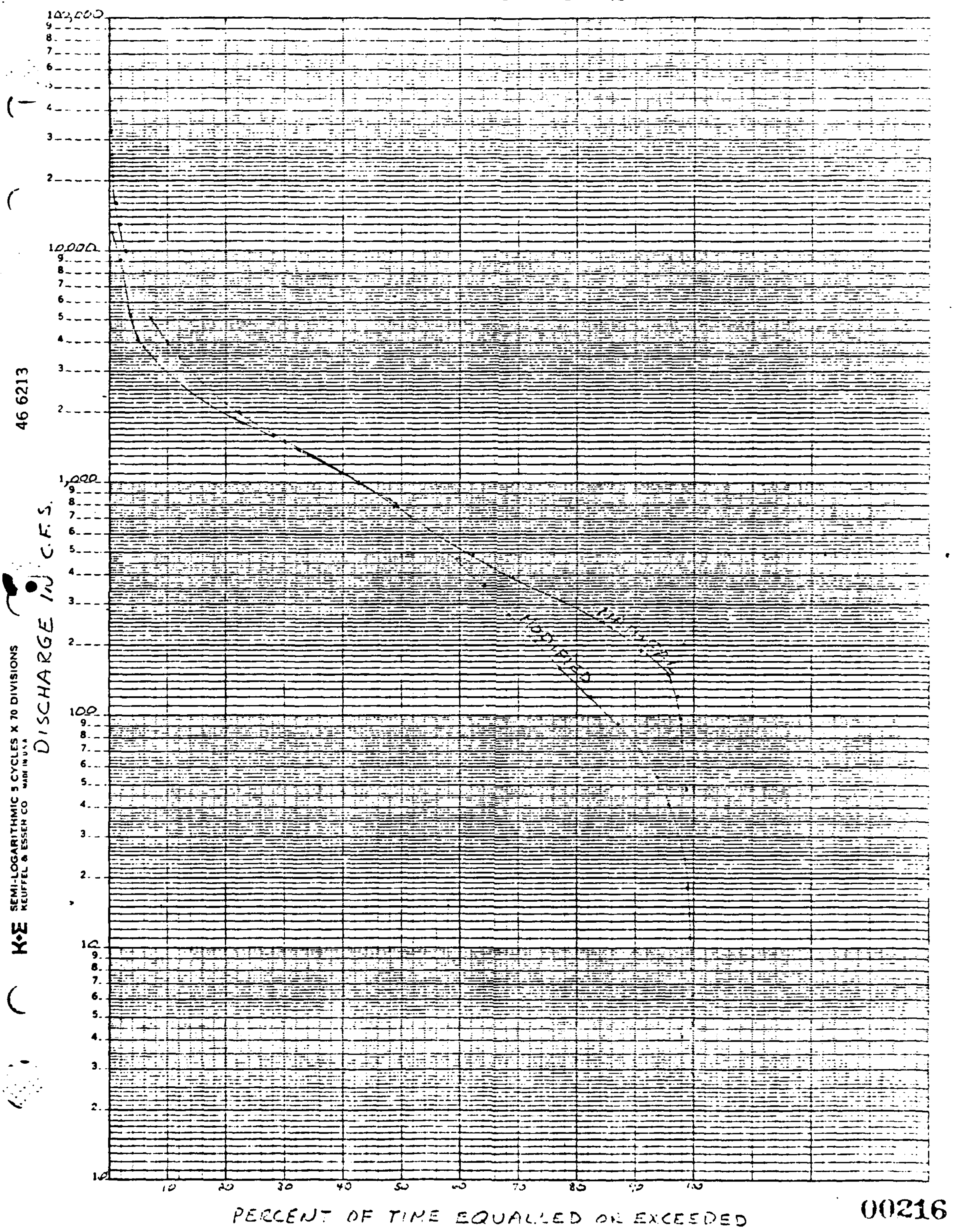
FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 3/80 AT 1559 SEQ 1.0001

STATION = 07198030/USGS ILLINOIS R NR GORE,OK 1952-1977 07198000/USGS



00215

TENKILLER- ILLINOIS R.



00216

STORET RETRIEVAL DATE 80/10/21 - STAND - VERSION OF SEP. 1980 STN 1.SUMMARY.1
WQ DATA 3 TO 5 MILES BELOW TENKILLER DAM

07198000
35 34 23.0 095 04 07.0 2
ILLINOIS R NR GORE,OK
40135 OKLAHOMA SEQUOYAH
100991

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 53/10/31 TO 80/07/08

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	266	0	12	0	12	12	12	85	45	0
MEAN	12.16	0.0	1.83	0.	1.167	9.92	8.	*********	1.113	0.0
MEDIAN	11.50	0.0	1.00	0.	1.000	10.00	3.	10.200	0.100	0.0
NO OF VIOLS	7	0	0	0	0	0	0	18	7	0
PERCENT VIOL	3.	0.	0.	0.	0.	0.	0.	21.	16.	0.
MINIMUM VIOL	21.50	0.0	0.0	0.	0.0	0.0	0.	2.600	1.700	0.0
MEAN VIOL	24.50	0.0	0.0	0.	0.0	0.0	0.	4.506	5.957	0.0
MAXIMUM VIOL	28.00	0.0	0.0	0.	0.0	0.0	0.	5.900	9.000	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	6.000	*********	*********
MAX CRITERIA	20.00	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

STORET RETR DATE 80/10/21 - STAND - VERSION OF SEP. 1980 STV 1.SUMMARY.2
JD DATA 3 T... MILES BELOW TENKILLER DAM

07...000
35 34 23.0 095 04 07.0 2
ILLINOIS R NR GORE,OK
40135 OKLAHOMA SEQUOYAH
100991

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 53/10/31 TO 80/07/08

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	12	0	10	0	400	400	9	12	12	34
MEAN	8.50	0.0	0.620	0.0	7.654	7.654	2.222	1.75	12.	2.753
MEDIAN	7.50	0.0	0.500	0.0	7.700	7.700	1.000	1.50	4.	2.000
NO OF VIOLS	0	0	0	0	6	0	0	0	0	1
PERCENT VIOL	0.	0.	0.	0.	2.	0.	0.	0.	0.	3.
MINIMUM VIOL	0.0	0.0	0.0	0.0	4.500	0.0	0.0	0.0	0.	11.000
MEAN VIOL	0.0	0.0	0.0	0.0	5.783	0.0	0.0	0.0	0.	11.000
MAXIMUM VIOL	0.0	0.0	0.0	0.0	6.500	0.0	0.0	0.0	0.	11.000
MIN CRITERIA	*********	*********	*********	*********	6.500	*********	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	*********	9.000	10.000	50.00	5000.	10.000

STORET RETRIEVAL DATE 80/10/21 - STAND - VERSION OF SEP. 1980
WQ DATA 3 TO 5 MILES BELOW TENKILLER DAM

2170046X10Z204 07198000
35 34 23.0 095 04 07.0 2
ILLINOIS RIVER NEAR GORE
40135 OKLAHOMA
ARKANSAS RIVER 1009
ILLINOIS RIVER
210KOSHO
0000 FEET DEPTH CLASS 00

STN 2.SUMMARY.1

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 59/10/01 TO 80/07/10

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	54	0	13	0	13	13	13	53	51	0
MEAN	12.84	0.0	2.46	0.	1.231	9.92	8.	*********	0.134	0.0
MEDIAN	11.50	0.0	1.00	0.	1.000	10.00	3.	9.700	0.100	0.0
NO OF VIOLS	5	0	0	0	0	0	0	9	0	0
PERCENT VIOL	9.	0.	0.	0.	0.	0.	0.	17.	0.	0.
MINIMUM VIOL	20.50	0.0	0.0	0.	0.0	0.0	0.	2.600	0.0	0.0
MEAN VIOL	24.10	0.0	0.0	0.	0.0	0.0	0.	4.411	0.0	0.0
MAXIMUM VIOL	29.00	0.0	0.0	0.	0.0	0.0	0.	5.900	0.0	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	6.000	*********	*********
MAX CRITERIA	20.00	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

STORET RETR... DATE 80/10/21 - STAND - VERSION OF SEP. 1980 STN 2.SUMMARY.2

JQ DATA 3 TO MILES BELOW TENKILLER DAM

21 JA6X10Z204 07198000
35 34 23.0 095 04 07.0 2
ILLINOIS RIVER NEAR GORE
40135 OKLAHOMA
ARKANSAS RIVER 1009
ILLINOIS RIVER
210KOSHD
0000 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 59/10/01 TO 80/07/10

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	13	0	11	0	252	252	10	13	13	54
MEAN	9.38	0.0	0.609	0.0	7.721	7.721	2.500	1.05	12.	4.465
MEDIAN	9.00	0.0	0.500	0.0	7.749	7.749	1.000	2.00	4.	2.000
NO OF VIOLS	0	0	0	0	1	0	0	0	0	4
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	0.	0.	7.
MINIMUM VIOL	0.0	0.0	0.0	0.0	6.399	0.0	0.0	0.0	0.	11.000
MEAN VIOL	0.0	0.0	0.0	0.0	6.399	0.0	0.0	0.0	0.	30.750
MAXIMUM VIOL	0.0	0.0	0.0	0.0	6.399	0.0	0.0	0.0	0.	77.000
MIN CRITERIA	*********	*********	*********	*********	6.500	*********	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	*********	9.000	10.000	50.00	5000.	10.000

1. Project Name: CONCHAS LAKE

2. Project Location: Conchas dam is at river mile 745 on the Canadian river which is a tributary to the Arkansas river. The Canadian river watershed above Conchas is 7,409 square miles. The flood control operation is automatic. Irrigation water is released directly into the Arch-Hurley canal.

3. Type of Project:

a. General category: multi-purpose.

b. Storage allocations:

	Elevation (Feet NGVD	Storage (Acre-feet)	(Inches-runoff)
Flood Control	4201-4218	259,600	0.66
Water Supply	4155-4201	198,800	0.50
Minimum	4155	75,500	0.18

c. Hydropower category: No power.

4. Water Management Criteria:

a. Authorized project purpose: flood control, water supply.

b. Water use contracts: Arch-Hurley Irrigation District.

c. Interagency agreements: none.

d. Informal commitments: none.

e. Systems regulation objectives: Operated in compliance with the Canadian River Compact.

5. Project Evaluation:

a. Effects of impoundment on water stored:

(1) Positive effects: Turbidity is lessened due to deposition of sediment.

(2) Negative effects:

(3) Negative effects: River downstream of the dam is reduced to an unnatural state as stream flow is nil except for times of major flooding.

(4) Cause of negative effects: All water, except major floods are stored and removed via irrigation canal.

c. Project effects on system regulation: No system regulation.

6. Constraints on Obtaining Instream Quantity and Quality Objectives.

a. Quantity: All flow appropriated under state law.

b. Quality:

7. Alternatives.

a. Reservoir regulation. None.

b. Structural modification. None.

c. Storage reallocation. Not applicable.

8. Actions Taken to Date: None.

9. Planned Actions: None.

1. Project Name: Optima Lake

2. Project Location: River mile 623.2 on North Canadian River tributary to Arkansas River. Project watershed (2,341 square miles) located in Oklahoma; downstream management control stations located in Oklahoma.

3. Type of Project:

a. General Category: multiple-purpose storage reservoir (exluding hydropower)

b. Storage Allocations:

	Elevation (feet N.G.V.D.)	Storage Ac. Ft.	Storage Inches of Runoff
Top Flood Control Pool	2779.0	229,500	1.84
Top Conservation Pool	2763.5	129,000	1.03
Bottom Conservation Pool	2726.0	11,350	.09
Water Supply Storage (10 mgd)		76,200	

4. Water Management Criteria:

a. Authorized Project Purpose: flood control, water supply and recreation.

b. Water Use Contracts: None

c. Interagency Agreements: None

d. Informal Commitments: None

e. System Regulation Objectives: Optima Lake is operated in a system with Ft. Supply and Canton. During flood control operation releases are made to retain equivalent flood control capabilities with these projects.

5. Project Evaluation:

a. Effects of impoundment on water stored:

1. Positive effects:

a. Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

2. Negative effects:

a. Quality: Due to the basin morphometry, Optima Lake stratifies only occasionally. Such weak and ephemeral stratification is not associated with water quality degradation.

6. Project Effect on Instream Flows:

1. General: Only natural discharge frequency and duration curves are available. The project was not full as of November 1980.

2. Negative effects: No water quality information was available for Optima tailwaters. Based on knowledge of the impoundment, it is doubtful significant violations of Oklahoma standards occur.

3. Project effects on system regulation: The project will have significant flood controlling effects on the North Canadian River.

7. Alternatives:

a. Reservoir Regulation: None

b. Structural Modification: None

c. Storage Reallocation: None

d. Other: No action

8. Action Taken to Date: None

9. Planned Action: None

OPTIMA
NORTH CANADIAN RIVER, OKLAHOMA

Top of Conservation (Power) Pool Elevation	2763.5
Top of Flood Control Pool Elevation	2779.0

OUTLET WORKS

Type	Conduit
Size	12'x16' Invert Fill
Intake Elevation	2708.0
Control Gates	2-5.67'x13'
Capacity at Conservation Pool (c.f.s.)	6200
Capacity at Flood Control Pool (c.f.s.)	7100

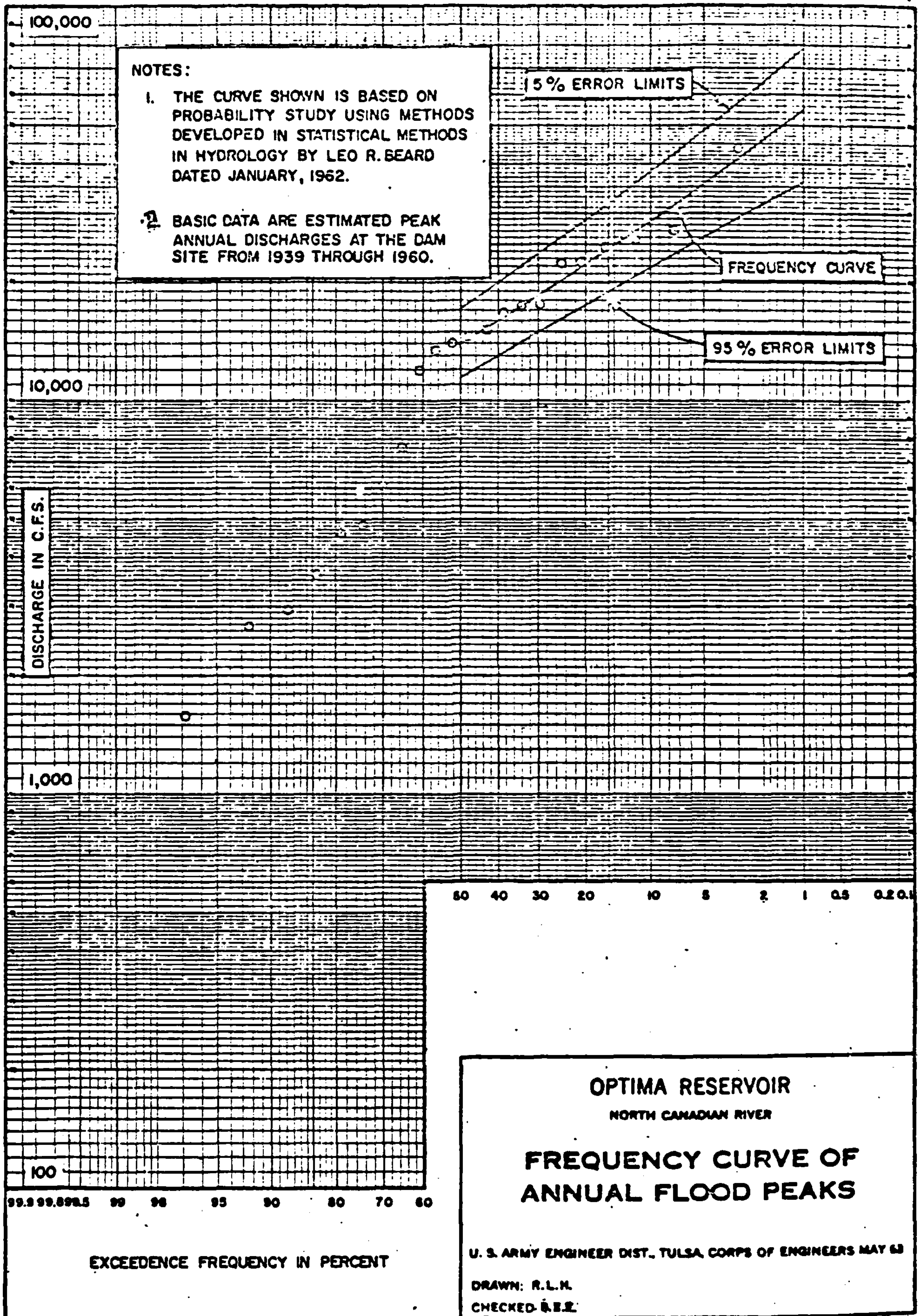
WATER SUPPLY FACILITY

Low Flow	
Type	Pipe
Size	36" Dia.
Elevation	2722.5
Capacity at Conservation Pool (c.f.s.)	224
Static Head Pipe	
Diameter	24" Dia.
Elevation	2722.5

SPILLWAY

Type	Excavated
Crest Width	1500'
Crest Elevation	2796.0
Control	Uncontrolled
Capacity at Conservation Pool (c.f.s.)	0
Capacity at Flood Control Pool (c.f.s.)	0

CORPS OF ENGINEERS U. S. ARMY



OPTIMA RESERVOIR

NORTH CANADIAN RIVER

FREQUENCY CURVE OF ANNUAL FLOOD PEAKS

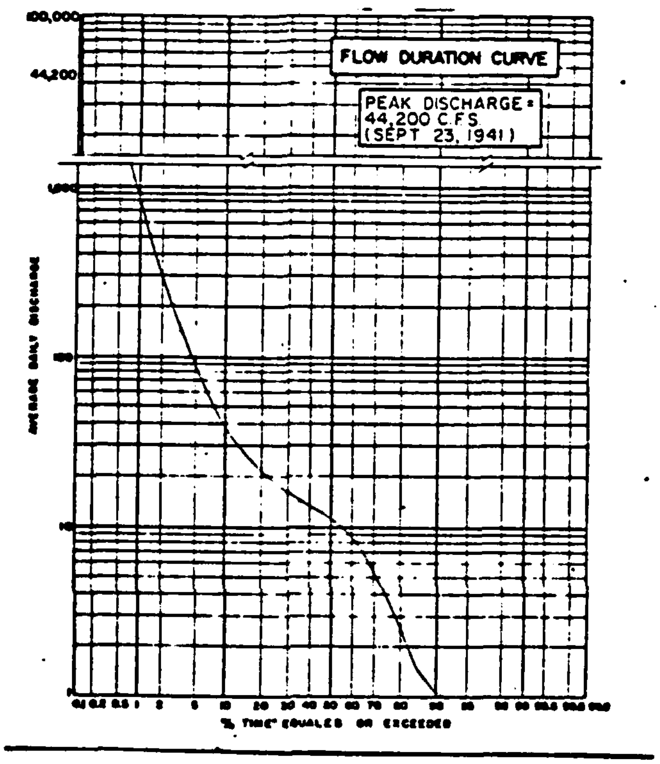
U. S. ARMY ENGINEER DIST., TULSA, CORPS OF ENGINEERS MAY 63

DRAWN: R.L.H.

CHECKED: B.E.E.

PLATE 9

PLATE 9



NOTE:
Duration curve computed from estimated mean daily flow for the period May 1939 through September 1966.

KEY	DATE	CHANGE	REVISION (INDICATED BY Δ)	APPR

U.S. ARMY ENGINEER DISTRICT TULSA
CORPS OF ENGINEERS
TULSA, OKLAHOMA

DESIGNED BY: DAC

DRAWN BY:

CHECKED BY: EEH

ARKANSAS RIVER WATERSHED N CANADIAN RIVER, OKLAHOMA

OPTIMA DAM
OUTLET WORKS
HYDROGRAPHS 1951-1962
AND FLOW DURATION CURVE
OPTIMA DAM SITE

SUBMITTED:
[signature]
CHIEF, HYDRAULICS BRANCH
DATE NOV. 1968

INVITATION NO DACW56-70-B-0045
SCALE AS SHOWN
DRAWING NO. 1220-C2-99/2

1. Project Name: Fort Supply Lake

2. Project Location: River mile 5.5 on Wolf Creek tributary to North Canadian River. Project watershed (1,735 square miles) located in Oklahoma; downstream management control stations located in Oklahoma.

3. Type of Project:

a. General Category: Multiple-purpose storage reservoir (excluding hydropower).

b. Storage Allocations:

	Elevation Feet (N.G.V.D.)	Storage Acre-Feet	Storage Inches Runoff
Top Flood Control Pool	2028.0	100,700	1.26
Top Conservation Pool	2004.0	13,900	.17
Bottom Conservation Pool	0	0	0
Water Supply Storage (.2 mgd)		400	

c. Hydropower Category: None.

4. Water Management Criteria:

a. Authorized Project Purpose: Flood control and conservation storage.

b. Water Use Contracts: Water storage - 0.2 mgd.

c. Interagency Agreements: None.

d. Informal Commitments: None.

e. System Regulation Objectives: Fort Supply Lake is operated in a system with Optima and Canton. During flood control operation releases are made to retain equivalent flood control capabilities with these projects.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(2) Negative effects:

Quality: Due to the basin morphometry, Fort Supply Lake stratifies only occasionally. Such weak and ephemeral stratification is not associated with water quality degradation.

b. <u>Project Effect on Instream Flows</u>:

(1) General: Discharge frequency and duration curves for natural and modified conditions are attached.

(2) Positive effects: A reduction of flood peak flow magnitudes has been observed since impoundment.

(3) Negative effects: No water quality information was available for Fort Supply tailwaters. Based on knowledge of the impoundment, it is doubtful significant violations of Oklahoma standards occur. A reduction of low flows has occurred since impoundment.

c. <u>Project Effects on System Regulation</u>: The project has a significant effect on the flood control capabilities on the North Canadian River system.

6. <u>Alternatives</u>:

a. <u>Reservoir Regulation</u>: None.

b. <u>Structural Modification</u>: None.

c. <u>Storage Reallocation</u>: None.

d. <u>Other</u>: No action.

7. <u>Action Taken to Date</u>: None.

8. <u>Planned Action</u>: None.

FORT SUPPLY
WOLF CREEK, OKLAHOMA

Top of Conservation (Power) Pool Elevation	2004.0
Top of Flood Control Pool Elevation	2028.0

OUTLET WORKS

Type	Conduit
Size	17.7' Dia. Equiv.
Intake Elevation	1979
Control Gates	3-7.5'x16'
Capacity at Conservation Pool (c.f.s.)	5500
Capacity at Flood Control Pool (c.f.s.)	9350

WATER SUPPLY FACILITY

Low Flow	
Type	Pipe
Size	36" Dia.
Elevation	1980
Capacity at Conservation Pool (c.f.s.)	200
Capacity at Flood Control Pool (c.f.s.)	286

SPILLWAY

Type	Chute
Crest Width	540
Crest Elevation	2028
Control	Uncon
Capacity at Conservation Pool (c.f.s.)	0
Capacity at Flood Control Pool (c.f.s.)	0

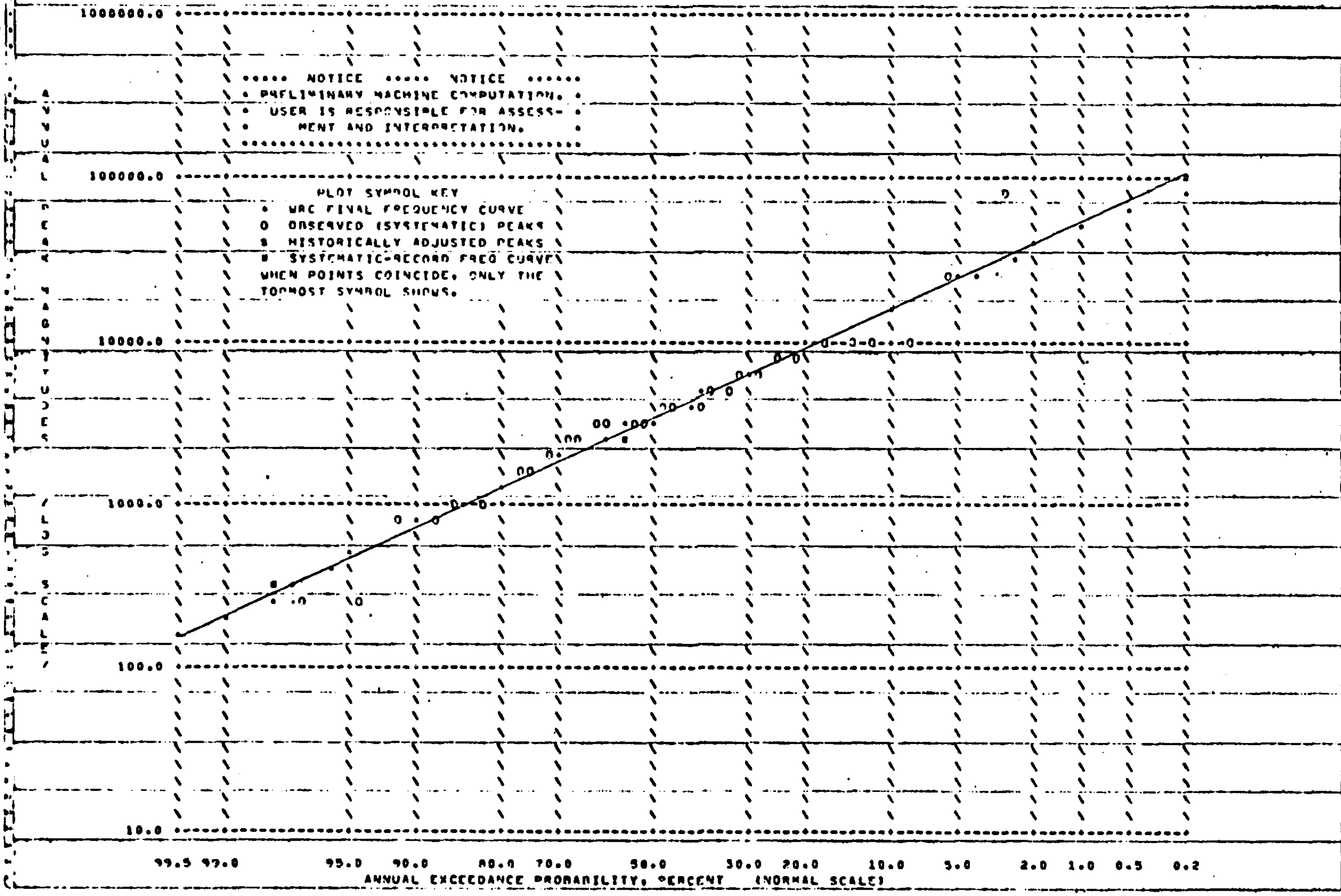
FORT SUPPLY -ORIG.

PGM J407 VER 3.4
(REV 10/22/79)

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 4/80 AT 1119 SEQ 1.0001

STATION - 07236190/USGS WOLF CREEK NR FARGO, OK 1943-1975 07236000/USGS



00231

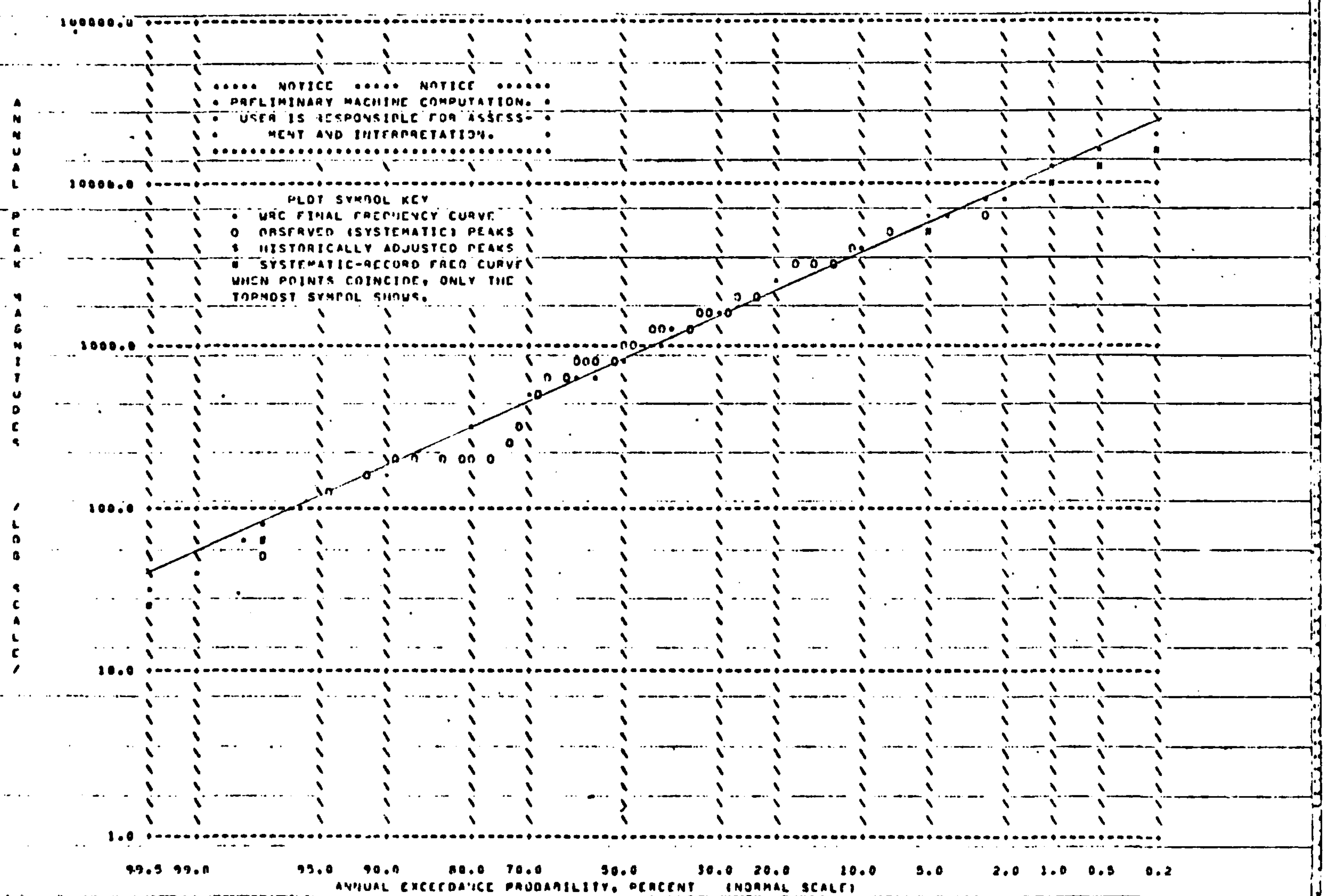
FORT SUPPLY-1 D

PGM J407 VER 3.4
(REV 10/22/79)

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

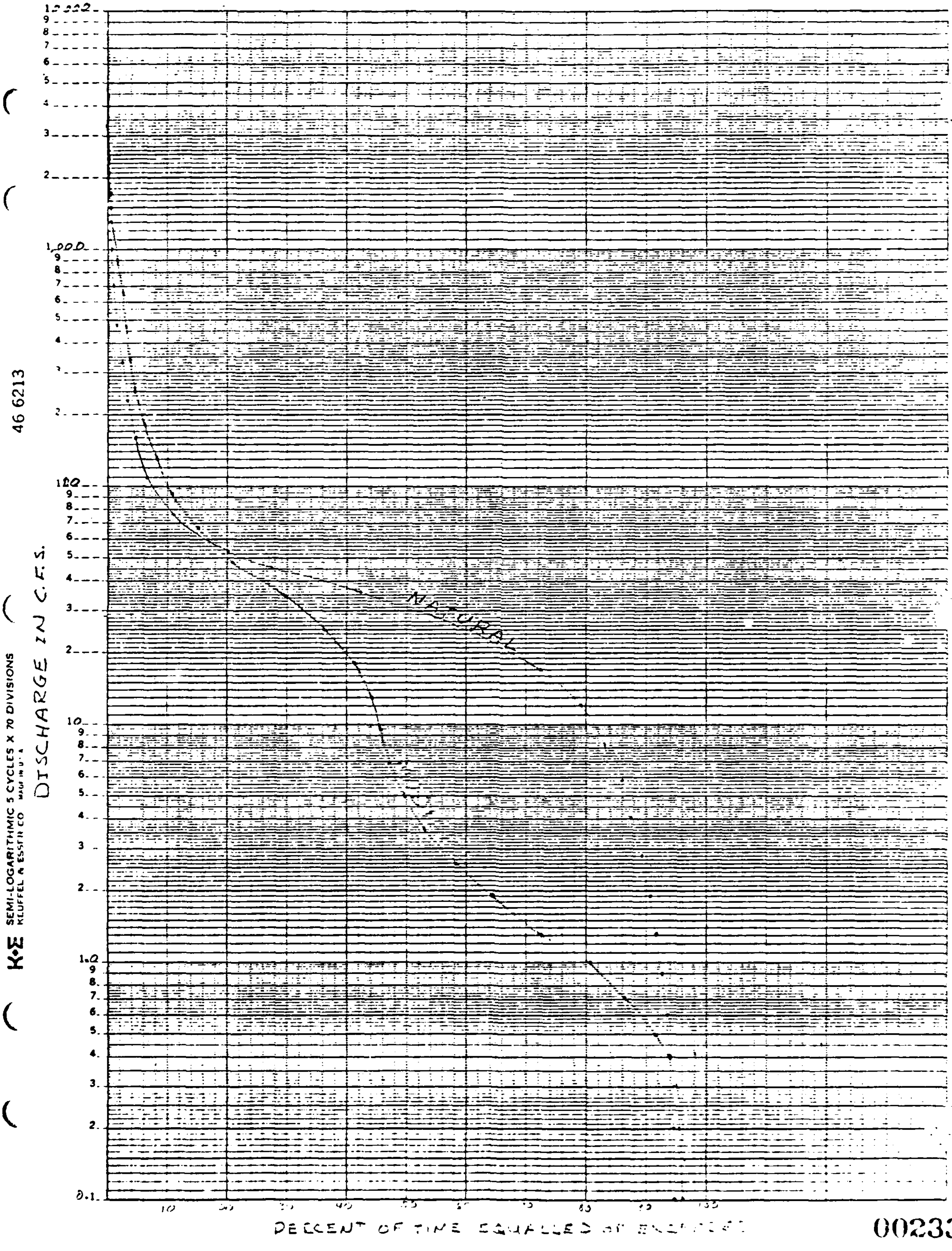
FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 7/80 AT 1143 SEQ 1.0001

STATION - 07237000/USGS WOLF CREEK NR FORT SUPPLY, OK 1941-1977 07237000/USGS



00232

Fort Supply - Wolf Ck



00233

1. Project Name: Canton Lake

2. Project Location: River mile 394.3 on North Canadian River tributary to Arkansas River. Project watershed (7,600 square miles) located in Oklahoma; downstream management control stations located in Oklahoma.

3. Type of Project:

a. General Category: multiple-purpose storage reservoir (excluding hydropower).

b. Storage Allocations:

	Elevation (Feet N.G.V.D.)	Storage Ac. Ft.	Inches of Runoff
Top Flood Control Pool	1638.0	383,800	.95
Top Conservation Pool	1601.6	36,200	.10
Bottom Conservation Pool	1596.5	18,500	.05
Water Supply Storage 10 mgd		38,000	
Irrigation 2 mgd		69,000	

4. Water Management Criteria:

a. Authorized Project Purpose: flood control, water supply, and irrigation.

b. Water Use Contracts:

Water storage	10 m.g.d. (5yr rental)
Irrigation	1.5 m.g.d. (5 yr rental)

c. Interagency Agreements: Agreements with Department of Interior to provide 69,000 acre-feet of storage for irrigation.

d. Informal Commitments: Agreements with Canton Lake Association to regulate for Walleye Rodeo in May.

e. System Regulation Objectives: Canton Lake is operated in a system with Ft. Supply and Optima. During flood control operation releases are made to retain equivalent flood control capabilities with these projects.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive Effects:

Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(2) Negative Effects:

Quality: Due to the basin morphometry, Canton Lake stratifies only occasionally. Such weak and ephemeral stratification is not associated with water quality degradation.

6. Project Effect on Instream Flows:

(1) General: Discharge frequency and duration curves are attached (both natural and modified conditions).

(2) Positive Effects: Reduction in peak flows and increases in low flows have been observed since impoundment.

(3) Negative Effects: Water supply releases for Oklahoma City can cause tailwater fluctuations to be greater than normal on a daily basis. Historical data from Canton tailwater stations were compared to Oklahoma raw water supply standards (see attachments). These drinking water standards were used because Oklahoma has few numerical standards for other water classes. No significant violations of these standards were found.

c. Project Effects on System Regulations: The project adds a significant flood control capability to the North Canadian River.

6. Constraints on Obtaining Instream Quality and Quality Objectives: Downstream releases for Oklahoma City water supply requirements may lower the lake level enough to cause problems in the wildlife management program in the lake area.

7. Alternatives:

a. Reservoir Regulation: None.

b. Structural Modification: None.

c. Storage Reallocation: None.

d. Other: No action.

8. Action Taken to Date: None.

9. Planned Action: None.

CANTON
NORTH CANADIAN RIVER, OKLAHOMA

Top of Conservation (Power) Pool Elevation	1618.5
Top of Flood Control Pool Elevation	1638.0

OUTLET WORKS

Type	Sluice	Rect. Conduit (Irrigation)
Size	3-7'x12'	7.5'x8.0'
Intake Elevation	1582.0	1590.0
Control Gates	3-7'x12'	2-4.0'x5.0'
Capacity at Conservation Pool (c.f.s.)	9750	Not Comp.
Capacity at Flood Control Pool (c.f.s.)	12,450	

WATER SUPPLY FACILITY

Low Flow	
Type	Pipe
Size	2-24" Dia.
Elevation	1583.0
Capacity at Conservation Pool (c.f.s.)	181
Capacity at Flood Control Pool (c.f.s.)	226

SPILLWAY

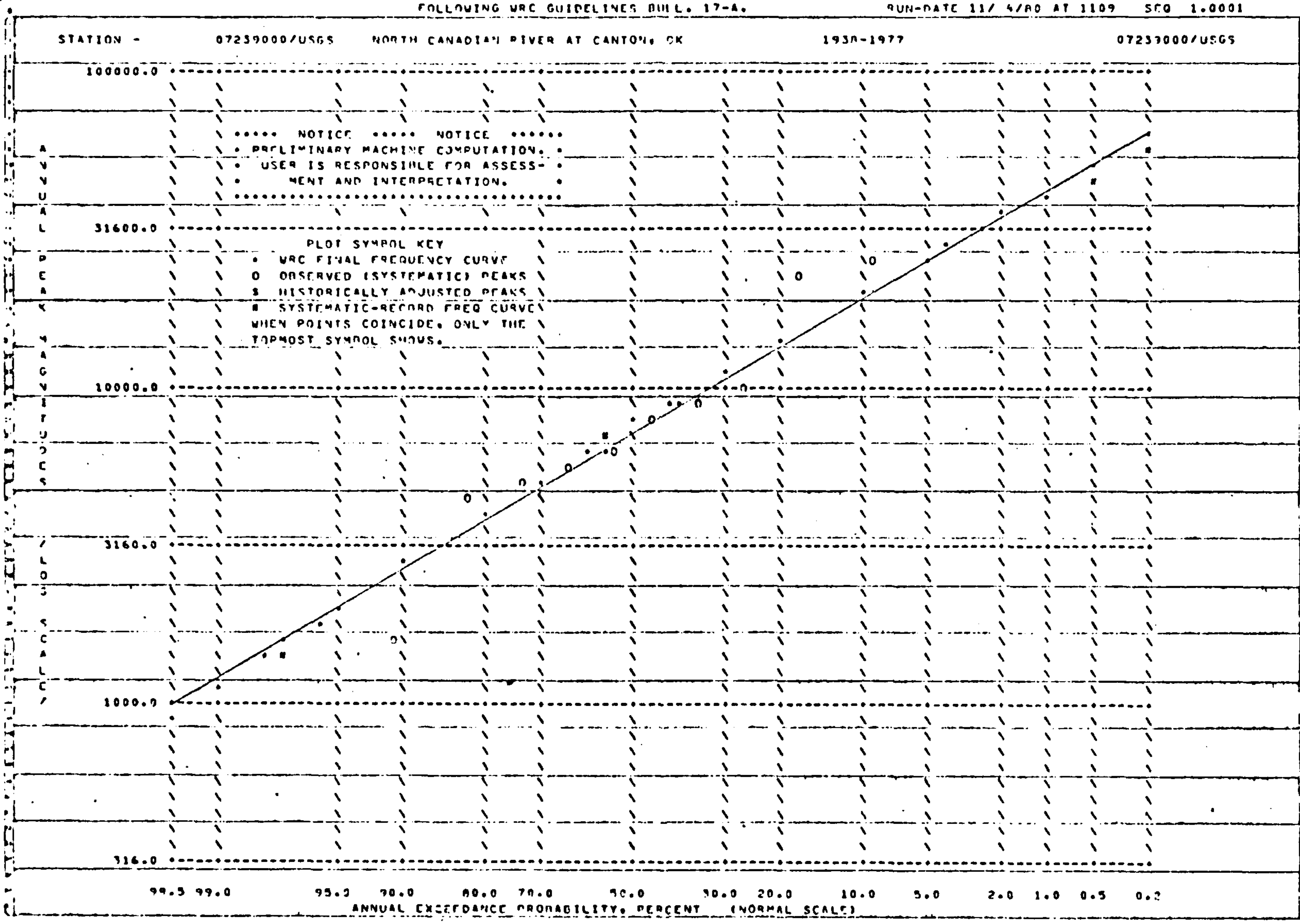
Type	Ogee
Crest Width	640'
Crest Elevation	1613.0
Control	16-40'x25' (Tainter Gates)
Capacity at Conservation Pool (c.f.s.)	33,000
Capacity at Flood Control Pool (c.f.s.)	275,000

CANTON - NATURAL

PGM J407 VER 3.4
(REV 10/22/79)

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 4/80 AT 1109 SEQ 1.0001



00237

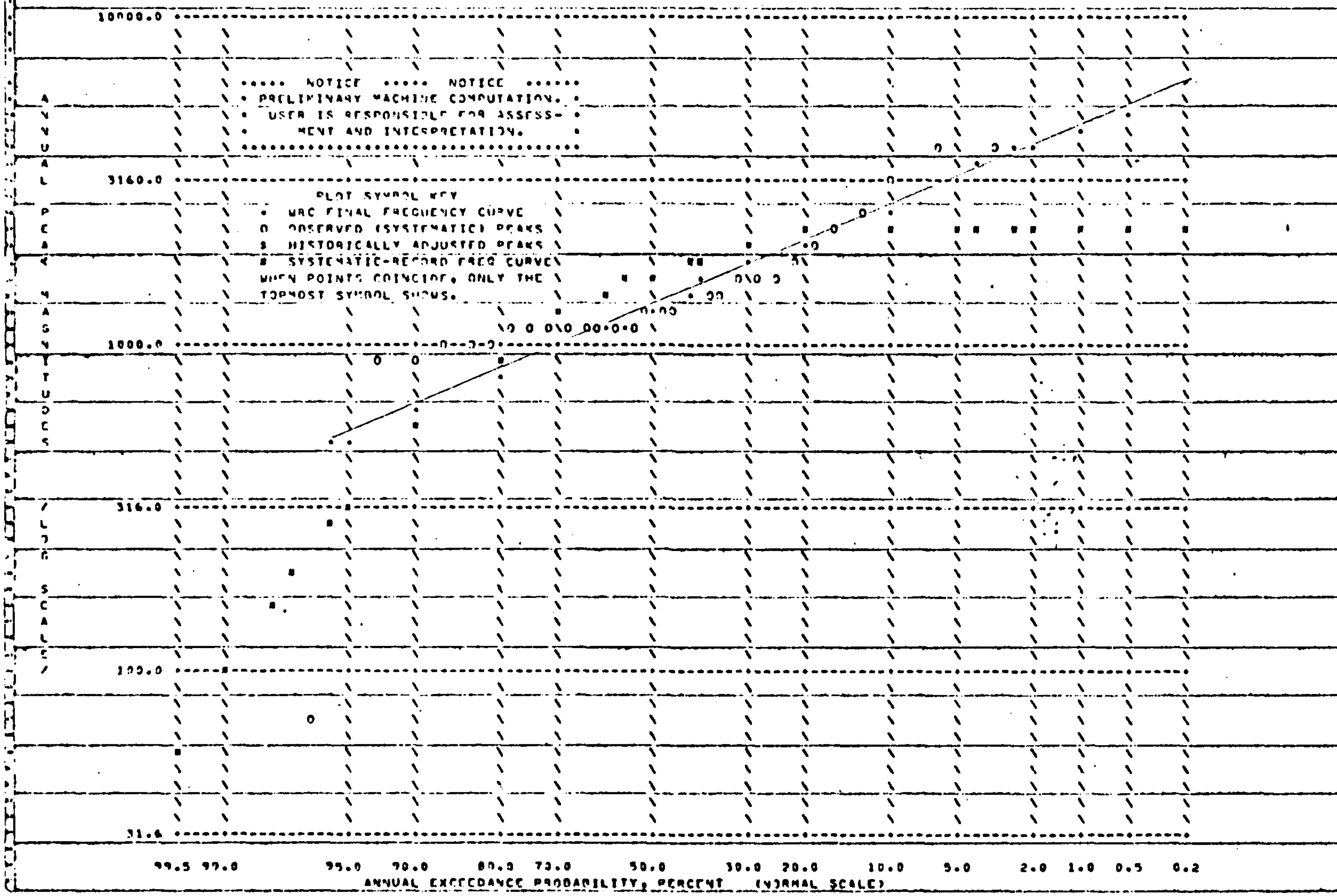
J407 VER 3.4
V 10/22/79)

U. S. GEOLOGICAL
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

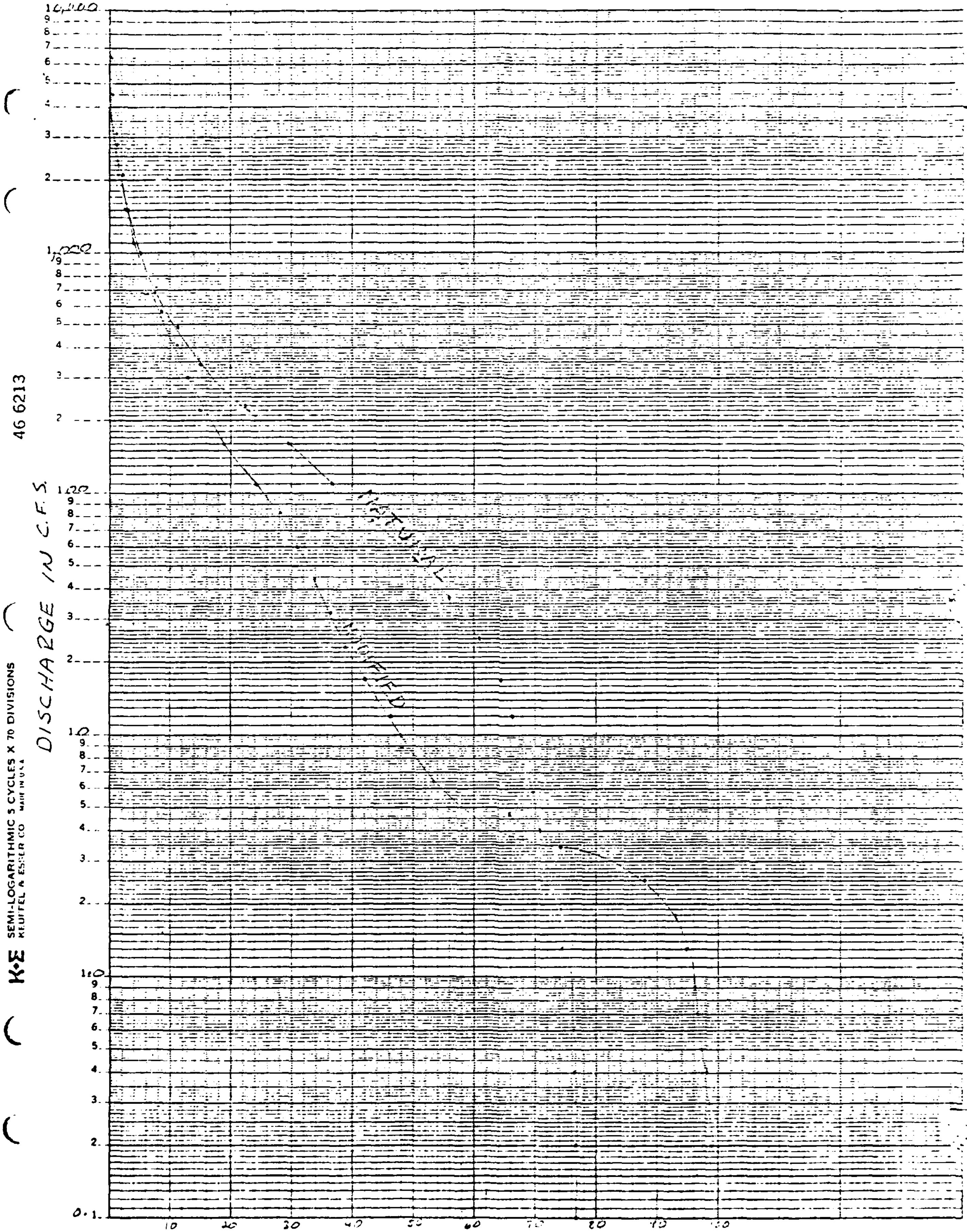
FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 3/80 AT 1402 SEQ 1.0001

CANTON MODIFIED

STATION - 07239000/USGS NORTH CANADIAN RIVER AT CANTON, OK 1948-1977 07239000/USGS



CANTON - NORTH CANADIAN R



00239

STORET RE... AL DATE 80/10/10 - STAND - VERSION OF SEP. 1980 STN 1.SUMMARY.1
WQ DATA O... LES BELOW CANTON

,9000
36 04 45.0 098 35 25.0 2
NORTH CANADIAN RIVER AT CANTON, OK
40011 OKLAHOMA BLAINE

/TYPA/AMBNT/STREAM

112WRD 760630
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 51/10/31 TO 79/10/02

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	48	0	12	0	12	12	12	44	45	0
MEAN	16.87	0.0	5.67	0.	2.000	16.50	7.	9.843	0.700	0.0
MEDIAN	19.00	0.0	5.50	0.	2.000	12.00	5.	9.300	0.700	0.0
NO OF VIOLS	0	0	0	0	0	0	0	0	0	0
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MEAN VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

STORET RETRIEVAL DATE 80/10/10 - STAND - VERSION OF SEP. 1980 STN 1.SUMMARY.2
WQ DATA 0.3 MILES BELOW CANTON

07239000
36 04 45.0 098 35 25.0 2
NORTH CANADIAN RIVER AT CANTON, OK
40011 OKLAHOMA BLAINE

/TYPA/AMBNT/STREAM

112WRD 760630
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 51/10/31 TO 79/10/02

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	12	0	9	0	94	94	9	12	12	36
MEAN	21.08	0.0	0.856	0.0	7.903	7.903	1.889	2.83	12.	13.23
MEDIAN	20.50	0.0	0.500	0.0	8.050	8.050	1.000	2.00	12.	9.20
NO OF VIOLS	0	0	1	0	0	1	0	0	0	0
PERCENT VIOL	0.	0.	11.	0.	0.	1.	0.	0.	0.	0.
MINIMUM VIOL	0.0	0.0	3.600	0.0	0.0	0.0	0.0	0.0	0.	0.0
MEAN VIOL	0.0	0.0	3.600	0.0	0.0	0.0	0.0	0.0	0.	0.0
MAXIMUM VIOL	0.0	0.0	3.600	0.0	0.0	0.0	0.0	0.0	0.	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	6.500	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	9.000	*********	10.000	50.00	5000.	50.00

1. Project Name: Eufaula Lake

2. Project Location: River mile 27.0 on Canadian River, tributary to Arkansas River. Project watershed (47,522 square miles) located in Oklahoma; downstream management control stations located in Oklahoma and Arkansas.

3. Type of Project:

a. General Category: Multiple-purpose storage reservoir (including hydropower).

b. Storage Allocations:

	Elevation (feet N.G.V.D.)	Storage Acre-Feet	Storage Inches Runoff
Top Flood Control Pool	597.0	3,798,000	8.47
Top Conservation Pool	585.0	2,330,000	5.20
Bottom Conservation Pool	565.0	865,000	1.93
Water Supply Storage (50 mgd)		56,000	

c. Hydropower Category: Peak demand.

4. Water Management Criteria:

a. Authorized Project Purposes: flood control, water supply, navigation, and hydropower.

b. Water Use Contracts: Existing water storage - (9) - 1.5 mgd; pending water storage - (3) - 2.2 mgd; existing water withdrawal - (10) - 0.35 mgd; pending water withdrawal - (2) - 0.09 mgd.

c. Interagency Agreements:

(1) SPA markets power.

(2) Oklahoma Department of Wildlife Conservation is making a study to improve fish and wildlife conditions in the lake area.

d. Informal Commitments: With SPA to provide power releases for downstream water quality at least every third day.

e. System Regulation Objectives: Regulated in the system to maximize power generation and to control floods while retaining equivalent flood control capabilities with other projects in the system insofar as possible.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive Effects:

Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(2) Negative Effects:

Quality: Eufaula becomes thermally stratifies from early summer through mid-fall. Chemical reactions within the anoxic hypolimnion cause an increase in dissolved iron and maganese within this zone. The water in the hypolimnion decreases in pH and temperature while amnonia and hydrogen sulfide levels are elevated. When the lake returns to complete mixing in the fall, the water quality becomes more desirable.

(3) Cause of negative effects: Soils within the watershed are high in iron and manganese. Agricultural operations lead to large input of these soils to the lake.

6. Project Effect on Instream Flows:

(1) General: Discharge frequency and duration curves for natural and modified conditions are attached.

(2) Positive effects: Reductions in peak flows are noted. No significant changes are noted in the duration curves.

(3) Negative effects: Power generation causes tailwater fluctuations to be greater than normal on a daily basis. Historical data from Eufaula tailwater stations were compared to Oklahoma Raw Water Supply Standards (see attachments). These drinking water standards were used because Oklahoma has few numerical standards for other water classes. Lead and manganese were the only parameters which frequently violated standards.

(4) Cause of negative effects: Water withdrawn from the hypolimnion for power generation is anoxic. Chemical reactions cause lead and manganese levels to be elevated. Manganese is a common constituent of soils in this region but the cause of high lead levels is unknown.

c. Project effects on system regulation: The project has a major affect on the flood control capability of the Canadian River and Arkansas River navigation system.

7. Constraints on Obtaining Instream Quantity and Quality Objectives:
Unable to make selective water level withdrawals for downstream releases. The flood control and power releases are determined by and limited to the requirements specified by the navigation taper needs. Downstream channel capacity has decreased due to farming in river channel.

8. Alternatives:

a. Reservoir regulation: none

b. Structural modification: A selective withdrawal system would unable better quality releases to be made.

c. Storage reallocation: None

d. Other: Destratification of the main pool would improve the quality of the releases.

e. No action:

9. Action Taken to Date: Destratification tests conducted in 1967-1968 did improve the quality of releases, however, full destratification of the main pool was not accomplished.

10. Planning Action: none

EUFAULA
CANADIAN RIVER, OKLAHOMA

Top of Conservation (Power) Pool Elevation	585.0 (Power)
Top of Flood Control Pool Elevation	597.0

OUTLET WORKS

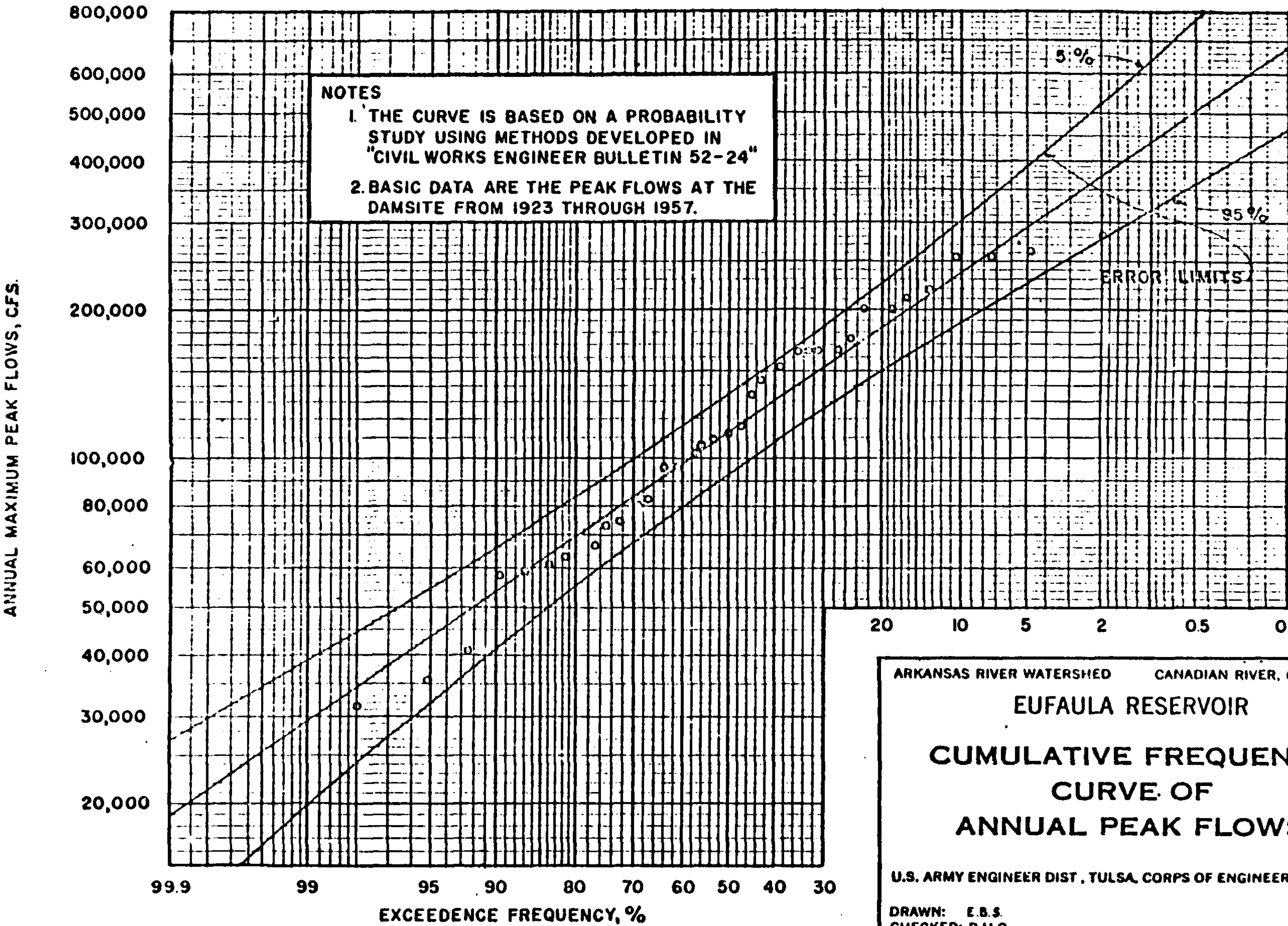
Type	Penstock
Size	3-22' Dia.
Intake Elevation	506.0
Control Gates	
Capacity at Conservation Pool (c.f.s.)	
Capacity at Flood Control Pool (c.f.s.)	

WATER SUPPLY FACILITY

Low Flow	
Type	Sluice
Size	5.67'x7'
Elevation	500
Capacity at Conservation Pool (c.f.s.)	2270
Capacity at Flood Control Pool (c.f.s.)	2390

SPILLWAY

Type	Ogee
Crest Width	440'
Crest Elevation	565.0
Control	11-40'x32'
Capacity at Conservation Pool (c.f.s.)	147,400
Capacity at Flood Control Pool (c.f.s.)	330,000



NOTES

1. THE CURVE IS BASED ON A PROBABILITY STUDY USING METHODS DEVELOPED IN "CIVIL WORKS ENGINEER BULLETIN 52-24"
2. BASIC DATA ARE THE PEAK FLOWS AT THE DAMSITE FROM 1923 THROUGH 1957.

ARKANSAS RIVER WATERSHED CANADIAN RIVER, OKLAHOMA

EUFAULA RESERVOIR

CUMULATIVE FREQUENCY CURVE OF ANNUAL PEAK FLOWS

U.S. ARMY ENGINEER DIST., TULSA, CORPS OF ENGINEERS, DEC. 58

DRAWN: E.B.S.
CHECKED: R.H.C.

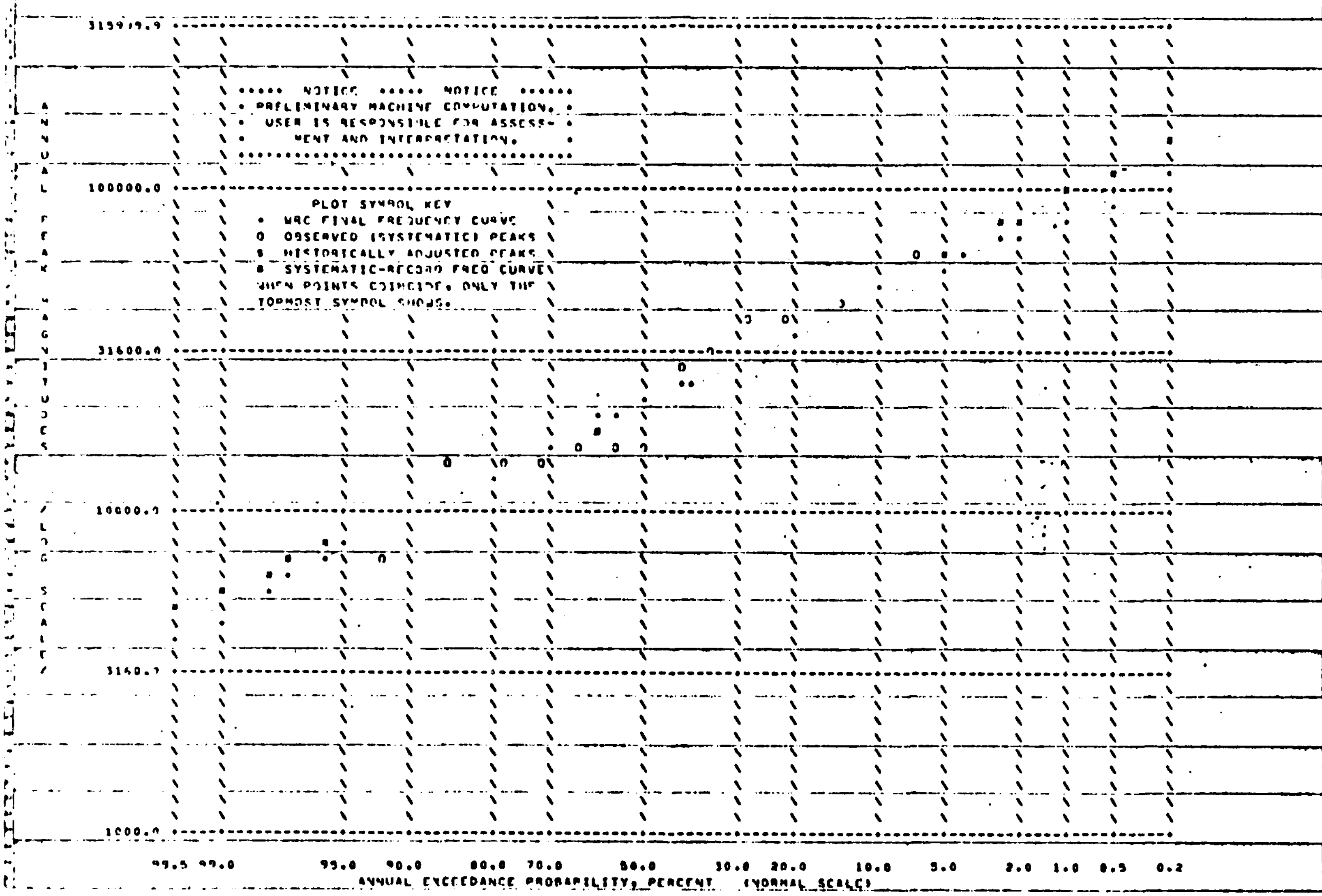
EUFAULA

PGM J407 VER 3.6
(REV 10/22/79)

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

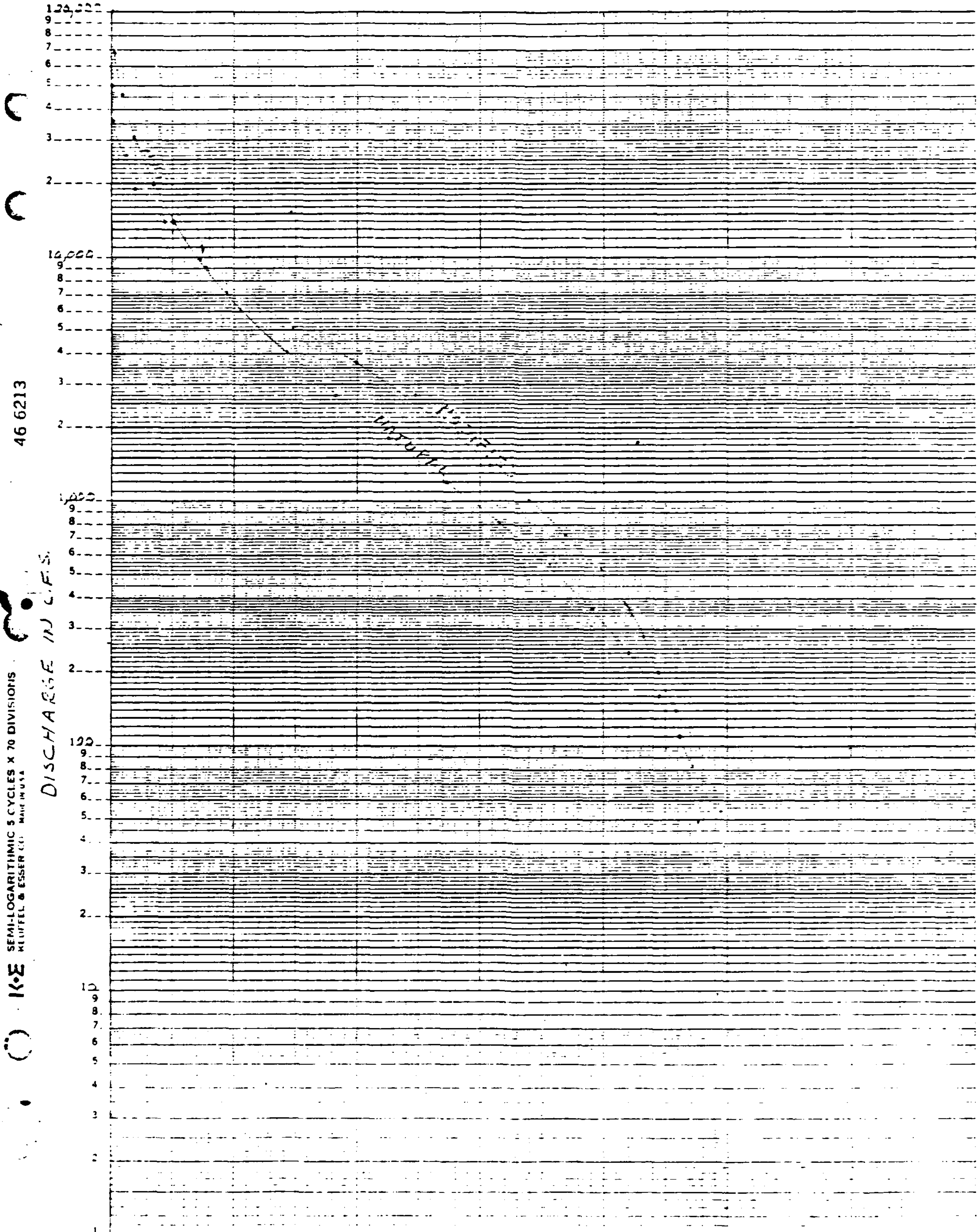
FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 3/80 AT 1500 SEQ 1.0001

STATION - 07245000/USGS CANADIAN RIVER NR WHITEFIELD, OK 1964-1977 07245000/USGS



00247

EUFAULA - CANADIAN R.



STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 1.SUMMARY.1
WQ DATA 8.2 MILES BELOW EUFAULA

07245000
35 15 45.0 095 14 19.0 2
CANADIAN RIVER NR WHITEFIELD, OK
40061 OKLAHOMA HASKELL
101392

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 64/02/06 TO 80/07/07

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	307	32	21	10	20	23	20	140	0	7
MEAN	15.38	0.103	1.33	150.	6.700	3.04	11.	9.393	0.0	512.9
MEDIAN	16.00	0.070	1.00	100.	10.000	0.0	10.	9.200	0.0	290.0
NO OF VIOLS	0	0	0	0	1	0	0	1	0	3
PERCENT VIOL	0.	0.	0.	0.	5.	0.	0.	1.	0.	43.
MINIMUM VIOL	0.0	0.0	0.0	0.	11.000	0.0	0.	4.000	0.0	310.0
MEAN VIOL	0.0	0.0	0.0	0.	11.000	0.0	0.	4.000	0.0	926.7
MAXIMUM VIOL	0.0	0.0	0.0	0.	11.000	0.0	0.	4.000	0.0	2100.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

STORET RETRIEV ATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 1.SUMMARY.2

.O DATA 9.2 MI BELOW EUFAULA

0724

35 15 45.0 095 14 19.0 2

CANADIAN RIVER NR WHITEFIELD, OK

40061 OKLAHOMA HASKELL

101392

/TYPA/AMBNT/STREAM

112WRD

0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 64/02/06 TO 80/07/07

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	20	20	19	0	622	622	20	21	20	39
MEAN	65.65	55.50	0.142	0.0	7.975	7.975	0.150	0.57	32.	14.67
MEDIAN	88.00	50.00	0.100	0.0	8.000	8.000	0.0	0.0	25.	9.00
NO OF VIOLS	13	9	0	0	6	7	0	0	0	1
PERCENT VIOL	65.	45.	0.	0.	1.	1.	0.	0.	0.	3.
MINIMUM VIOL	67.00	60.00	0.0	0.0	0.800	9.100	0.0	0.0	0.	130.00
MEAN VIOL	93.69	81.11	0.0	0.0	5.167	9.171	0.0	0.0	0.	130.00
MAXIMUM VIOL	100.00	140.00	0.0	0.0	6.500	9.300	0.0	0.0	0.	130.00
MIN CRITERIA	*********	*********	*********	*********	6.500	*********	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	*********	9.000	10.000	50.00	5000.	50.00

00250

1. Project Name: Robert S. Kerr Lock and Dam

2. Project Location: River Mile 336.2 on Arkansas River. Project watershed (147,756 square miles) located in Oklahoma.

3. Type of Project:

a. General Category: Navigation (including hydropower)

b. Storage Allocations:

	Elevation Feet (N.G.V.D.)	Storage Acre-Feet	Storage Inches Runoff
Top Power Pool	460.0	493,600	---
Bottom Power Pool	458.0	79,500	---

c. Hydropower Category: Run-of-river

4. Water Management Criteria:

a. Authorized Project Purpose: Navigation, hydropower, and recreation

b. Water Use Contracts: None

c. *Interagency Agreements: Southwestern Power Administration markets power.*

d. Informal Commitments: With the Ft. Smith United Way Campaign Committee to provide discharges for annual raft race in August or September.

e. System Regulation Objectives: A semi-run-of-river project that to a small degree reregulates the inflow to obtain the desired flow at Van Buren.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored: No significant effects are caused by this type of impoundment on the quality of the water.

b. Effects on Instream Flows: No significant effects are caused by this type of impoundment on the quality or quantity of flows.

c. Project Effects on System Regulation: The project provides for navigation on the Arkansas River System.

6. Alternatives:

a. Reservoir Regulation: None

b. Structural Modification: None

c. Storage Reallocation: None

d. Other: No action.

7. Action Taken to Date: None

8. Planned Action: None

1. Project Name: W. D. Mayo Lock and Dam

2. Project Location: River Mile 319.6 on Arkansas River. Project watershed (148.084 square miles) located in Oklahoma.

3. Type of Project:

a. General Category: Navigation (excluding hydropower)

b. Storage Allocations:

	Elevation Feet (N.G.V.D.)	Storage Acre-feet	Storage Inches Runoff
Top Maximum Pool	445.0	--	--
Upper Pool	413.0- 411.0	--	--

c. Hydropower Category: None

4. Water Management Criteria:

a. Authorized Project Purposes: Navigation

b. Water Use Contracts: None

c. Interagency Agreements: None

d. Informal Commitments: None

e. System Regulation Objectives: The project is basically a run-of-river project that has only minor regulating abilities.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored: No significant effects are caused by this type of impoundment on the quality of the water.

b. Effects on Instream Flows: No significant effects are caused by this type of impoundment on the quality or quantity of flows.

c. Project Effects on System Regulation: The project provides for navigation on the Arkansas River System.

6. Alternatives:

a. Reservoir Regulation: None

b. Structural Modification: None

c. Storage Reallocation: None

d. Others: No action

7. Action Taken To Date: None

8. Planned Action: None

1. Project Name: Wister Lake

2. Project Location: River mile 60.9 on Poteau River tributary to Arkansas River. Project watershed (993 square miles) located in Oklahoma; downstream management control stations located in Oklahoma and Arkansas.

3. Type of Project:

a. General Category: multiple-purpose storage reservoir (exluding hydro-power).

b. Storage Allocations:

	Elevation (feet, N.G.V.D.)	Storage Acre-Feet	Storage Inches of Runoff
Top Flood Control Pool	502.5	427,900	
Top Conservation Pool	471.6	27,100	.51
Bottom Conservation Pool	0	0	0
Water Supply Storage (6 mgd)		9,600	

4. Water Management Criteria:

a. Authorized Project Purpose: flood control and conservation

b. Water Use Contracts: Existing water storage - 4 mgd; pending water storage - 2 mgd.

c. Interagency Agreements: None

d. Informal Commitments: None

e. System Regulation Objectives: The project is regulated in the system to control floods while retaining equivalent flood control capabilities with other projects in the system.

5. Project Evaluation:

a. Effects of impoundment on water stored:

1. Positive effects:

a. Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

b. Quantity: The lake provides storage for flow augmentation in times of drought.

2. Negative effects:

a. Quality: Wister Lake becomes thermally stratified from early summer through mid-fall. Chemical reactions within the anoxic hypolimnion cause an increase in dissolved iron and manganese within this zone. The water in the hypolimnion decreases in pH and temperature while ammonia and hydrogen sulfide levels are elevated. When the lake returns to complete mixing in the fall, the water quality becomes more desirable.

b. Quantity: ~~Power generation causes tailwater fluctuations to be greater than normal.~~ X

c. Cause of negative effects: Soils within the watershed are high in iron and manganese. Agricultural operations lead to large input of these soils to the lake.

6. Project Effect on Instream Flows:

1. General: Discharge frequencies and duration curves for natural and modified conditions are attached.

2. Positive effects: Peak flow magnitudes have been reduced.

3. Negative effects: Historical data from Wister tailwater stations were compared to Oklahoma Raw Water Supply Standards (see attachments). These drinking water standards were used because Oklahoma has few numerical standards for other water classes. The only problem area found was pH levels. Approximately 29 percent of these samples were less than 6.5. Few violations of other parameters were noted.

4. Cause of negative effects: Water withdrawn from the hypolimnion for flood releases is anoxic. Chemical reactions cause this water to have a low pH.

5. Projects Effects on System Regulation: The project has a major flood control effect on the Poteau River.

7. Constraints on Obtaining Instream Quantity and Quality Objectives: Unable to make selective water level withdrawals for downstream releases. The flood control releases are determined by and limited to the requirements specified by the navigation taper or the Van Buren Guide Curve.

8. Alternatives:

a. Reservoir Regulation: None

b. Structural Modification: A selective withdrawal facility would improve the quality of the releases.

c. Storage Reallocation: None

d. Other: Destratification would improve the quality of the releases.

e. No Action.

9. <u>Action Taken to Date</u>: None

10. <u>Planned Action</u>: None

WISTER
POTEAU RIVER, OKLAHOMA

Top of Conservation (Power) Pool Elevation		471.6
Top of Flood Control Pool Elevation		502.5

OUTLET WORKS

Type		Conduit
Size		2-15.8'x14'
Intake Elevation		450.0
Control Gates		6-7'x12'
Capacity at Conservation Pool (c.f.s.)		7900
Capacity at Flood Control Pool (c.f.s.)		14,700

WATER SUPPLY FACILITY

Low Flow		
Type		Pipe
Size		30" Dia.
Elevation		451.0
Capacity at Conservation Pool (c.f.s.)		112
Static Head Pipe		
Diameter	12" Dia.	3" Dia.
Elevation	459.5	453.875

SPILLWAY

Type		Chute
Crest Width		600'
Crest Elevation		502.5
Control		Uncontrolled
Capacity at Conservation Pool (c.f.s.)		0
Capacity at Flood Control Pool (c.f.s.)		0

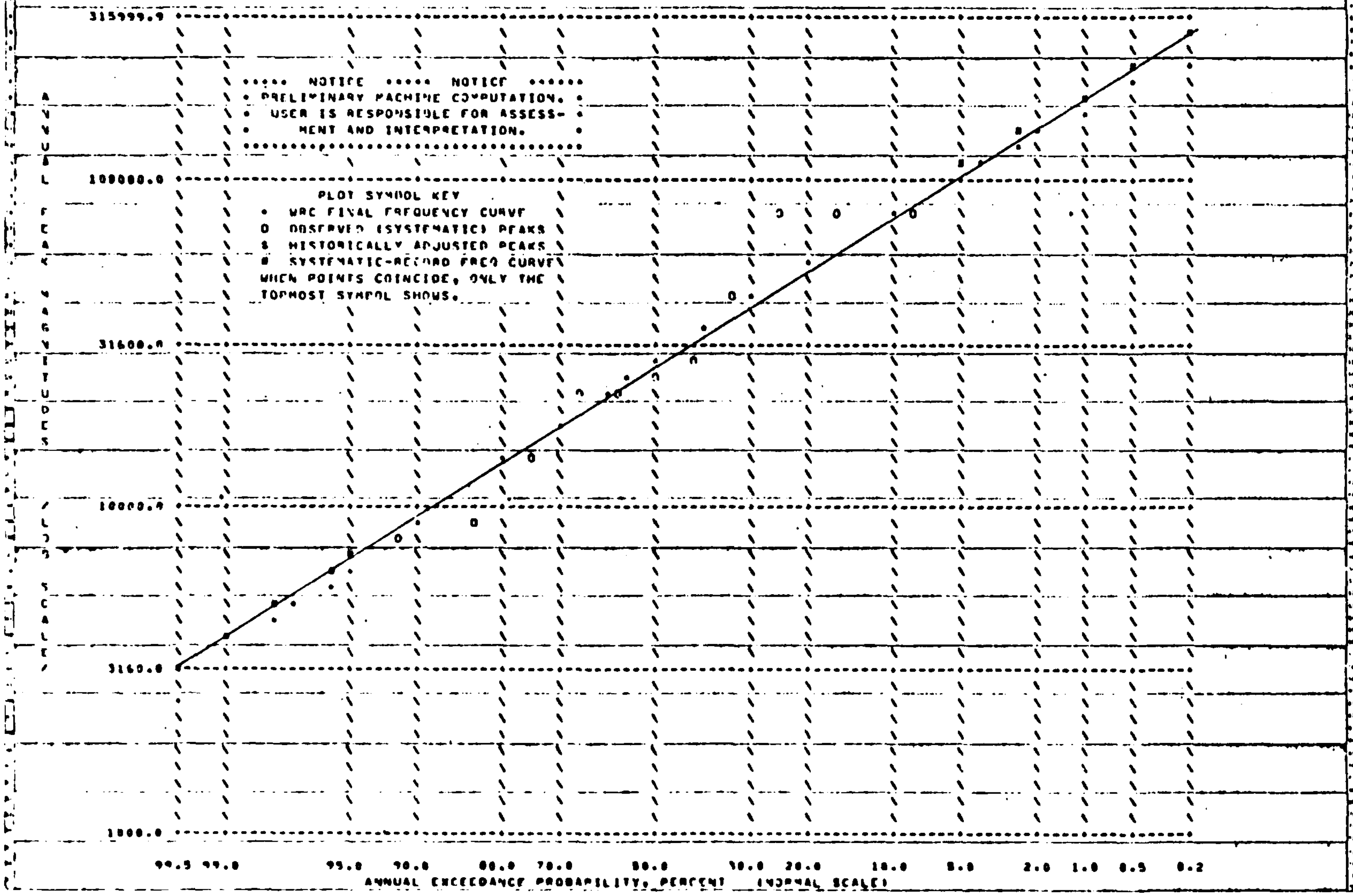
WISTER - ORIG

J407 VER 3.4
REV 10/22/79)

U. S. GEOLOGICAL [illegible]
ANNUAL PEAK FLOW FREQU[illegible] ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 4/80 AT 1139 SEQ 1.0001

STATION - 07249500/USGS POTEAU RIVER NR WISTER, OK 1939-1977 07249500/USGS



00259

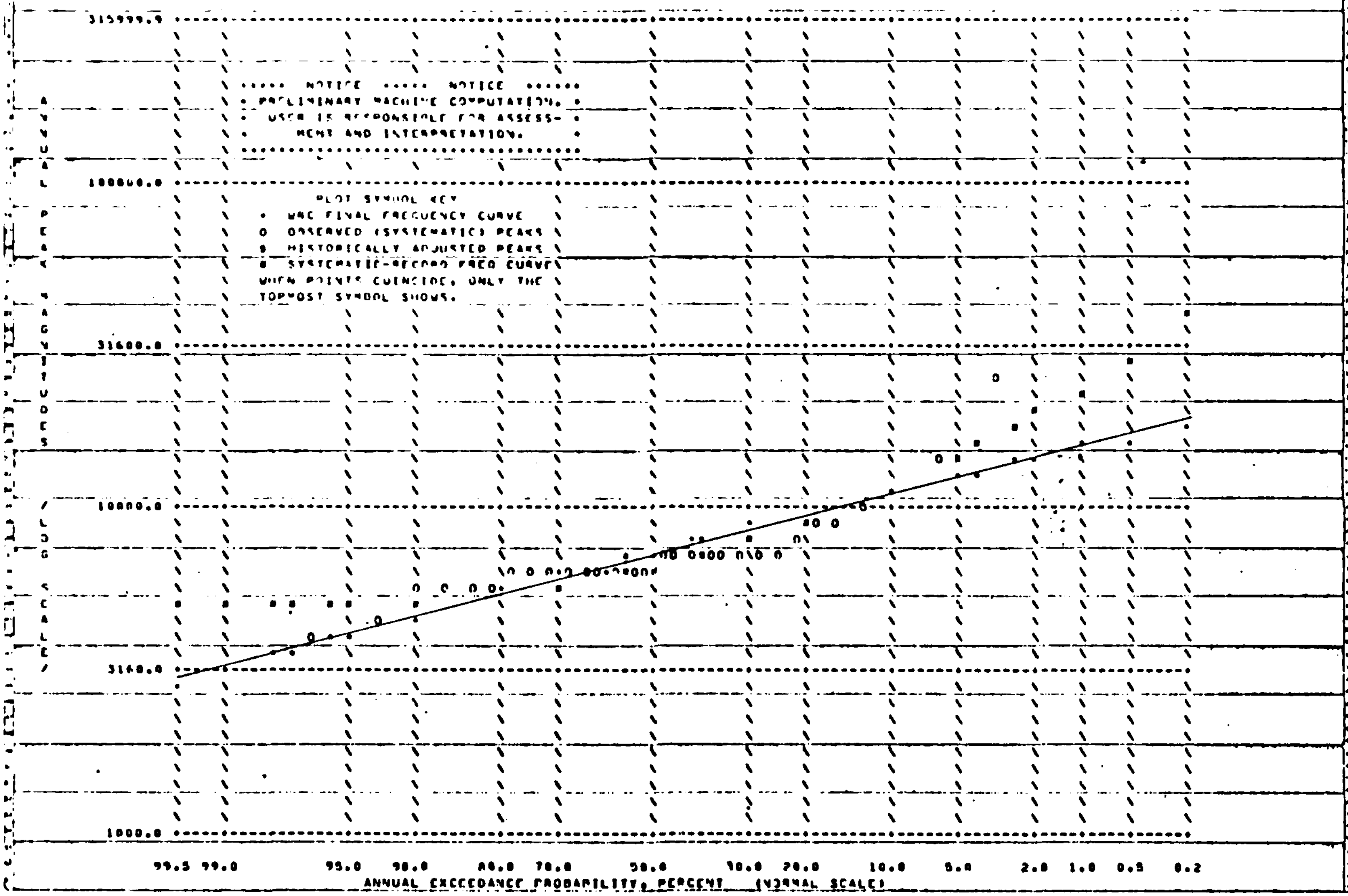
WISTER 2

PGM J407 VER 3.4
(REV 10/22/79)

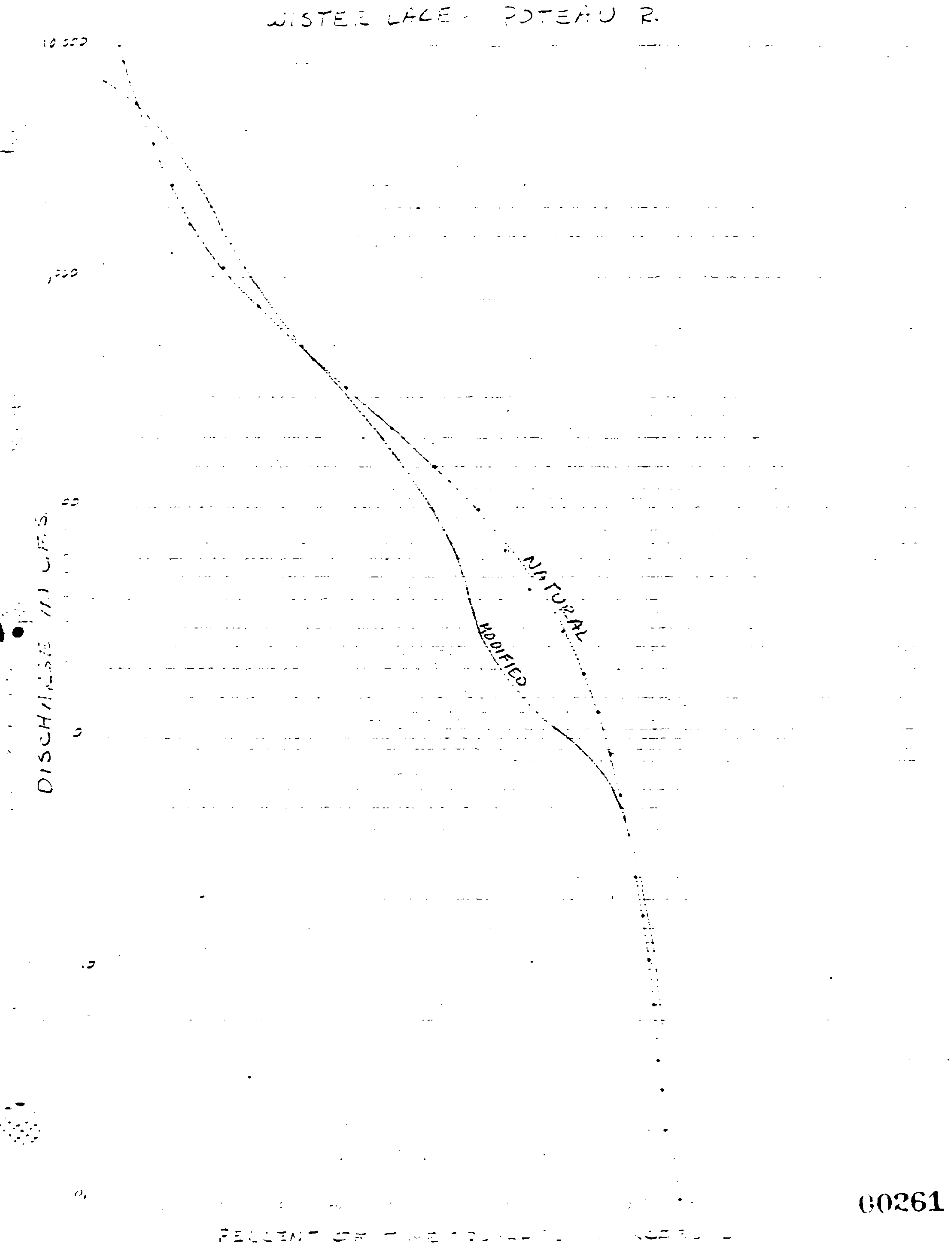
U. S. GEOLOGIC SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 3/80 AT 1608 SEQ 1.0001

STATION - 07249510/USGS POTEAU RIVER NR WISTER, OK 1940-1977 07249500/USGS



00260


WISTER LAKE - POTEAU R.
10,000
1,000
100
10
1.0
NATURAL
MODIFIED
DISCHARGE IN C.F.S.

00261

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 1.SUMMARY.1
WQ DATA AT WISTER STILLING BASIN

07248500
35 56 15.0 094 42 54.0 2
POTEAU RIVER NR WISTER, OK
40079 OKLAHOMA LE FLORE
100991

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 54/11/30 TO 79/10/11

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	45	0	10	0	10	10	10	44	42	0
MEAN	16.30	0.0	2.80	0.	1.200	12.00	4.	10.043	0.620	0.0
MEDIAN	17.00	0.0	2.00	0.	1.000	13.00	4.	9.650	0.100	0.0
NO OF VIOLS	0	0	0	0	0	0	0	0	3	0
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	0.	7.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	6.000	0.0
MEAN VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	7.000	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	8.000	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

STORET RETR DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 1.SUMMARY.2
WQ DATA AT ER STILLING BASIN

0. 3500
35 56 15.0 094 42 54.0 2
POTEAU RIVER NR WISTER, OK
40079 OKLAHOMA LE FLORE
100991

/TYPA/AMONT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 54/11/30 TO 79/10/11

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	10	0	8	0	108	108	7	10	10	32
MEAN	18.10	0.0	0.500	0.0	6.824	6.824	2.857	1.70	14.	37.78
MEDIAN	7.00	0.0	0.500	0.0	6.700	6.700	2.000	2.00	11.	39.50
NO OF VIOLS	1	0	0	0	32	1	0	0	0	5
PERCENT VIOL	10.	0.	0.	0.	30.	1.	0.	0.	0.	16.
MINIMUM VIOL	85.00	0.0	0.0	0.0	4.700	9.400	0.0	0.0	0.	55.00
MEAN VIOL	85.00	0.0	0.0	0.0	6.122	9.400	0.0	0.0	0.	59.00
MAXIMUM VIOL	85.00	0.0	0.0	0.0	6.500	9.400	0.0	0.0	0.	65.00
MIN CRITERIA	*********	*********	*********	*********	6.500	*********	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	*********	9.000	10.000	50.00	5000.	50.00

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980
WQ DATA AT WISTER STILLING BASIN

STN 2.SUMMARY.2

2010003X97201 07248500
34 56 15.0 094 42 54.0 2
POTEAU RIVER NEAR WISTER
40079 OKLAHOMA
ARKANSAS RIVER 1009
POTEAU RIVER
21OKOSHD 760910
0000 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 75/11/11 TO 80/07/16

	01051 LEAD PB,TOT UG/L	01054 MANGNES. MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	11	0	9	0	46	46	8	11	11	50
MEAN	17.73	0.0	0.500	0.0	7.339	7.339	3.500	1.82	13.	33.07
MEDIAN	9.00	0.0	0.500	0.0	7.250	7.250	3.000	2.00	11.	34.50
NO OF VIOLS	1	0	0	0	3	1	0	0	0	6
PERCENT VIOL	9.	0.	0.	0.	7.	2.	0.	0.	0.	12.
MINIMUM VIOL	85.00	0.0	0.0	0.0	6.300	9.400	0.0	0.0	0.	55.00
MEAN VIOL	85.00	0.0	0.0	0.0	6.367	9.400	0.0	0.0	0.	59.50
MAXIMUM VIOL	85.00	0.0	0.0	0.0	6.400	9.400	0.0	0.0	0.	65.00
MIN CRITERIA	*********	*********	*********	*********	6.500	*********	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	*********	9.000	10.000	50.00	5000.	50.00

00264

STORET R   VAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980

NO DATA   STER STILLING BASIN

STN 2.SUMMARY.1

.0083X92201 07248500
34 56 15.0 094 42 54.0 2
POTEAU RIVER NEAR WISTER
40079 OKLAHOMA
ARKANSAS RIVER 1009
POTEAU RIVER
210KOSHD 760910
0000 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 75/11/11 TO 80/07/16

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	51	1	11	0	11	11	11	50	47	0
MEAN	15.78	1.500	4.27	0.	1.182	11.45	5.	9.688	0.154	0.0
MEDIAN	17.00	1.500	2.00	0.	1.000	12.00	4.	9.250	0.100	0.0
NO OF VIOLS	0	1	0	0	0	0	0	0	0	0
PERCENT VIOL	0.	100.	0.	0.	0.	0.	0.	0.	0.	0.
MINIMUM VIOL	0.0	1.500	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MEAN VIOL	0.0	1.500	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MAXIMUM VIOL	0.0	1.500	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

Blue Mountain Lake - Instream Flow Problems and Needs Evaluation

1. Project Name: Blue Mountain Lake.

2. Project Location: Blue Mountain Dam is located on the Petit Jean River at river mile 74.4, 1 1/2 miles southwest of Waveland, Yell County, Arkansas. There are 488 square miles of drainage area above the dam, with downstream water management control stations at Danville and Centerville.

3. Type of Project:

a. General Category: Blue Mountain is one of several projects constructed in the Arkansas River Basin for flood control purposes only. The project also offers excellent recreational opportunities.

b. Storage Allocations:

Pool	Surface Elevation ft msl	Capacity: Acre Feet (1,000) Net	Acre Feet (1,000) Gross	Inches of Runoff Net	Inches of Runoff Gross
Minimum Conservation (Fall/Winter)	384	24.6	24.6	.9	.9
Seasonal Storage (Spring/Summer)	387	9.5	34.1	.4	1.3
Flood Control Storage					
- Fall/Winter	419	233.3	257.9	9.0	9.9
- Spring/Summer	419	223.8	257.9	8.6	9.9
Total	419	257.9	257.9	9.9	9.9

c. Outlets:

Type of Outlets	No. & Size	Invert El ft msl	Opening Size & Control	Max Discharge (cfs) at Top Cons	Max Discharge (cfs) at Top Flood
Tunneled Circular Conduit	1 - 20' dia	367	3 - 8' x 17' tractor gates	3,650	12,800

d. Hydropower Category: N/A

4. Water Management Criteria:

a. Authorized project purposes: Flood control only.

b. Water use contracts: None.

c. Interagency Agreements: None.

d. Informal Commitments: In accordance with an informal agreement with the Arkansas Game and Fish Commission (AG&FC) the regulation plan provides for the lake level to rise to elevation 387 on or about 15 April each year. It is maintained at that level until about mid-May to stimulate fish spawning and increase survival of larval fishes. Beginning about 15 May, the water level is then lowered slowly for mosquito control and to provide a minimum downstream release until elevation 384 is reached about 1 October. Except for periods of high inflow and during special operations, the lake remains at 384 until 15 April the following year. Periodically, the AG&FC has recommended

major (10 feet or more) drawdowns in the summer (1956, 1957, 1960, and 1965) or early fall to allow reseeding of the exposed bottom with rye or sudan grass and sorghum to improve water clarity. The drawdown also allows for the reduction of the rough fish population. The AG&FC then restocks the lake with sport fish the following spring.

e. System regulation objectives: Blue Mountain Lake is one unit in a group of projects authorized for control of floods in the Arkansas River Valley. The Petit Jean River is a comparatively small tributary, but at times it may increase flood heights on the Arkansas River. Also, the valley storage in the lower Petit Jean River is effective in modifying Arkansas River floods.

5. Project Evaluation:

a. General: Table 1 summarizes water quality data obtained during the period 1974 through 1980 upstream near Booneville, within the lake (7 stations), and downstream near Waveland and Danville. It contains mean values of up to 50 measurements taken at each location. The data indicate that certain constituents, such as turbidity, iron, and sulfates, settle out in the lake. They become concentrated in the lower depths, from which they are released. Nutrient concentrations do not change significantly in the lake or downstream, although the lake would be expected to act as a nutrient sink. Iron and manganese exceed the recommended levels for drinking water of 300 and 50 micrograms/liter, respectively, at all locations within the system.

Table 1
Blue Mountain Lake Project - WQ Data[1]

Parameter	Sample Location: Upstream[2]	Lake[3]	Downstream[4]
Turbidity (JTU)	24.5	8.7	10
Dissolved Oxygen (mg/l)	8.2	6.2[5]	8.6
Iron (ug/l)	1,750	1,300	2,600
Manganese (ug/l)	264	289	345
Fecal coliform (#/100ml)	538	15	3
Nitrates + nitrites (mg/l-N)	0.12	0.11	0.08
Phosphorus (mg/l)	0.05	0.03	0.03
pH (SU)	7.0	6.6	6.6
Sulfates (mg/l)	11.8	6.5	5.8

[1]Mean values of up to 50 measurements at each station.
[2]Near Booneville, Arkansas.
[3]At 7 stations on the lake.
[4]Near Waveland and Danville, Arkansas.
[5]Average values of samples taken at depths of 8 to 14 feet.

EPA's National Eutrophication Survey classified Blue Mountain Lake as eutrophic; i.e., nutrient rich and productive. Observed water quality in and downstream from Blue Mountain Lake reveals no deviations from the Arkansas water quality standards.

b. Effects of impoundment on water stored:

(1) Positive effects: The Petit Jean River has unusually high turbidity which is caused primarily by colloidal clay particles. Much of the suspended material washed into the lake settles out, and the colloidal turbidity is reduced somewhat by impoundment in Blue Mountain Lake. Thus the lake clarity is greater near the surface. The lake reduces the amount of iron and sulfates moving in the river. Manganese would be expected to exhibit the same pattern as iron, but the data indicate that it does not. This may indicate that insufficient data are available. Fecal coliforms entering the lake from tributaries during storm runoff die off in the lake. The impoundment reduces the velocity of flood waters, thus preventing further scouring.

(2) Negative effects: Blue Mountain Lake stratifies during the late summer and early fall. Measurements at depths of 4-12 feet have indicated dissolved oxygen concentrations exceeding 5 mg/l, but readings of 0.1-0.4 mg/l have been made at depths of 32-48 feet near the dam. Concentrations of several constituents are greater near the bottom. When stratification breaks up in late fall, increased concentrations of constituents such as dissolved iron and manganese are mixed throughout the impounded waters for a short period of time. Previous major drawdowns coordinated with the AG&FC included planting rye and sudan grass and sorghum on the exposed lake bottom. When inundated, this decaying vegetation helped reduce colloidal clay turbidity, contributed to lake fertility (for fishery purposes), and provided hiding places for larval fishes. It is possible that the decomposition of the vegetation may help deplete the dissolved oxygen in the lower depths of the lake in the early summer. However, the amount of material added is a fraction of that inundated during extended major flood periods. This organic material, along with that washed into the lake by floods, results in a reducing environment which produces hydrogen sulfide and other undesirable compounds.

(3) Causes of negative effects: The geology of the area is the reason for the high colloidal turbidity as well as the iron and manganese levels. The hydrogen sulfide problem is one which needs more detailed study. It appears to be related to oxygen depletion brought about by decay of organic material, but oxygen depletion occurs at other lakes which do not have problems with excessive hydrogen sulfide. Blue Mountain Lake is similar to Nimrod Lake in that frequently a substantial area subject to inundation is exposed in the early growing season, and terrestrial vegetation develops. This vegetation may then be inundated by stored flood waters in the late spring and early summer. Sulfides are normally formed from sulfates, but Blue Mountain Lake does not appear to have excessively high sulfates. Stratification is primarily a function of rising temperatures, and water quality deterioration in the lower depths follows stratification. Some of the

excessive turbidity is caused by the land use in the watershed, some because of wind action on the large area of shallow water, and some because of the rooting action of bottom feeding fish, such as carp and buffalo.

The primary purpose of Blue Mountain Lake is flood control; however, the lake is used extensively for recreation. At the present time there are seven recreation areas on the lake with three more planned for future development.

The area surrounding this segment of the river is mostly pasture land, which makes it a contributor to the eutrophic state of the lake.

There are two sewage treatment facilities (Booneville and Arkansas State Sanitarium, Children's Colony) located above Blue Mountain Lake. The high fecal coliform counts which have been noticed at times may be due to inadequate treatment at these sites.

This lake has two point sources of industrial waste. The Amerace-Esna Corporation in Booneville employs 400 people in the manufacture of hard rubber products and has a permit to discharge only treated wastewater. The Wolverine Toy Manufacturing Company just east of Booneville employs about 300 people.

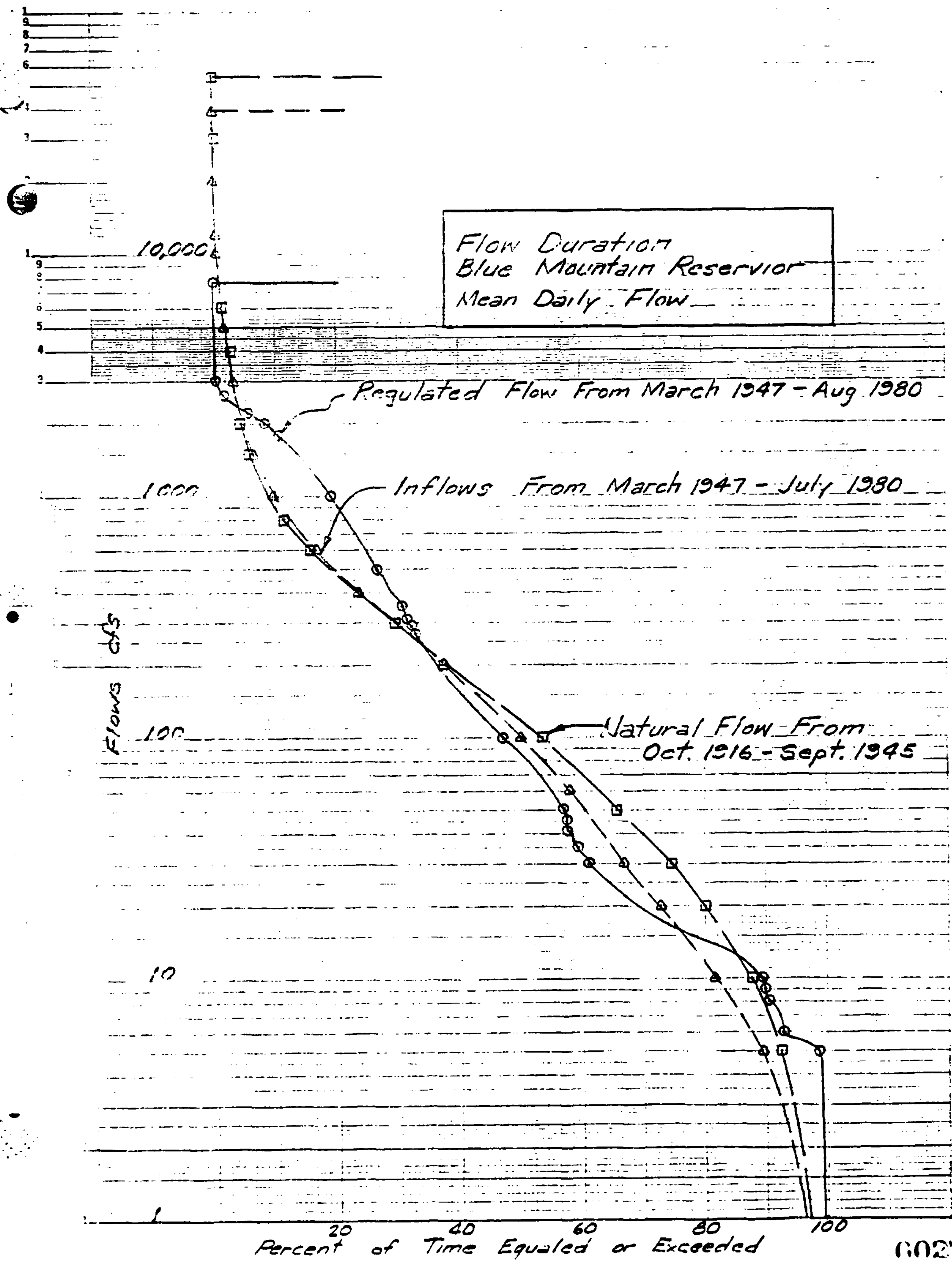
c. Project effects on instream flows:

(1) General: Discharge-duration curves for the project inflows and releases as well as natural flows are shown on the inclosed exhibit. The curves representing inflows and releases are for the period of record from March 1947 through July-August 1980. These values are calculated from reservoir control records using storage routing and rating curves. The curve representing natural condition flows is for a period of record from October 1916 through September 1945 and these values were calculated by:

(a) Daily flows previous to 16 January 1939 were estimated from runoff records on the Petit Jean River at Danville, Arkansas, by ratios determined from simultaneous records at Blue Mountain and Danville.

(b) Daily flows subsequent to 16 January 1939 are based on gage records and measurements at the Blue Mountain gage.

(2) Positive effects: The flood control features of the project reduce the high flows and increase the duration of flows around bank full downstream of the dam. The low flow releases are normally significantly greater than preproject low flows, and the minimum release of 5 cfs is an improvement over natural minimum flows, which frequently were zero. The 5 cfs minimum release was established to provide water for Danville and to replenish low flow pools downstream in the Petit Jean River for fishery purposes. During the initial stages of floods, releases may be stopped; however, runoff from uncontrolled areas downstream maintains flow in the channel. The fecal coliform levels in the releases are significantly less than in the inflows to the project.



Flow Duration
Blue Mountain Reservior
Mean Daily Flow
Regulated Flow From March 1947 - Aug 1980
Inflows From March 1947 - July 1980
Natural Flow From
Oct. 1916 - Sept. 1945
10,000
1000
100
10
Flows cfs
20
40
60
80
100
Percent of Time Equaled or Exceeded

60270

(3) Negative effects: As a result of flood control operations, the project increases the duration of flooding on marginal land bordering the Petit Jean River downstream. The water discharged downstream sometimes appears more turbid than the lake water because of stratification and density currents within the lake. The iron and manganese concentrations at the downstream sampling locations average more than in both the lakes and upstream of the dam. During the lake turnover period, excessive levels of iron and manganese are present in the releases. There are occasional strong odors below the dam which are caused by high levels of hydrogen sulfide in the releases. These normally occur when flood waters are being released.

(4) Cause of negative effects: The increased flooding of marginal land is considered negative because it adversely affects downstream landowners who attempt to utilize this land. Thus, the negative effect is brought about, or caused, by the use of the land. The turbidity of the downstream releases is related to the level in the lake from which the water is withdrawn and thus is due to the outlet configuration. The increase in iron and manganese concentrations during turnover is due to the circulation from the bottom of waters with significantly higher amounts of those metals. The possible cause of the occasional hydrogen sulfide problem has been discussed previously.

d. Project effect on system regulation:

(1) Blue Mountain is regulated independently from the upstream flood control reservoirs in the McClellan-Kerr Arkansas River Navigation System. In general, its regulated releases have little or no effect on Arkansas River flood flows and no recognized negative effects on quality or quantity.

(2) These regulated releases may have positive effects on the quantity of Arkansas River flows when stored flood water is being evacuated coincidently with marginal navigation taper flows and thereby can supplement minimal releases from the upstream reservoirs. They may have a positive effect on quality on rare occasions when such releases may coincide with extremely low flows on the Arkansas River and thereby dilute the salt content in the Arkansas River water.

6. Constraints on Obtaining Instream Quantity and Quality Objectives:

a. Quantity: The present minimum low flow release is 5 cfs. However, in most years, inflows to the lake are larger than this; and with these releases and those required to gradually lower the 3-foot seasonal raise in the conservation pool between 15 May and 30 September, the total releases are several times the minimum. This regulation plan is generally consistent with the recommendations of fishery biologists to provide stable releases during the spring and early summer months. In dry years with near zero inflows, the 5 cfs minimum release may be less than desired by fishery biologists or downstream water users.

b. Quality: A tradeoff exists between fishery management within the lake and the quality of the releases. As mentioned earlier, vegetation is planted

during major drawdowns to increase fertility in the lake and help clear the water. This practice, however, may contribute to degraded releases.

7. Alternatives:

a. Reservoir regulation: The present regulation plan is considered adequate for downstream quantity needs, although occasionally deviations are made to accommodate downstream users. A study is now underway to revise this plan to minimize the need for them.

b. Structural modification: It is possible that the problem of excessive hydrogen sulfide in the releases could be alleviated by the construction of a multilevel intake. This would allow release of water from closer to the surface, thus avoiding the higher concentrations of hydrogen sulfide near the bottom.

c. Storage reallocation: NA

d. Other: Previous major drawdowns have resulted in reduction in turbidity within the lake, evidently due to the drying out and "solidification" of the exposed lake bottom, the removal of large rough fish (bottom feeders), and the planting of vegetation on this exposed area. The decomposition of the vegetation provides the carbon dioxide necessary to flocculate the colloidal clays which inflow adds to the lake constantly. This practice is expected to be continued on a periodic basis to improve turbidity and for fishery management purposes, inasmuch as the benefits are tangible and the negative effects are speculative at best.

8. Actions Taken to Date: Major drawdowns for fishery management purposes were conducted in 1956, 1957, 1959, 1965, 1970, and 1977, at the request of the AG&FC. The drawdowns, which were coordinated with other fishery management techniques, were considered successful.

9. Planned Actions: A study is underway to determine the feasibility of using various alternative stages at Danville to regulate the project. A water quality study is proposed to determine the feasibility of various methods of avoiding the discharge of undesirable levels of constituents such as hydrogen sulfide, dissolved oxygen, turbidity, etc. This study would cost approximately $15,000 and would take 12 months to complete. It would primarily involve data collection and adaptation of the results of the more extensive proposed Nimrod Lake study. Unless supplemental funds were available, this study could not be started earlier than FY 83. A major drawdown for fishery management purposes will be scheduled when requested by the AG&FC.

Nimrod Lake - Instream Flow Problems and Needs Evaluation

1. Project Name: Nimrod Lake

2. Project Location: The dam is located at River Mile 62.6 on the Fourche LaFave River, a tributary to the Arkansas River. The project watershed is 680 square miles located in Perry and Yell Counties, Arkansas, with downstream water management control stations at Aplin, Hollis, Perryville, and Houston on the Fourche LaFave River and Hollis on the South Fourche River.

3. Type of Project:

a. General category· The project was constructed for flood control and generation of hydroelectric power, but it now includes water supply and is managed for fish and wildlife in addition to the authorized purpose. Recreation facilities were provided under the Flood Control Act of 1944, as amended.

b. Storage allocations:

Pool	Surface elevation (ft msl)	Capacity: Acre-feet (1000) Net	Acre-feet (1000) Gross	Inches of Runoff Net	Inches of Runoff Gross
Minimum Conservation (fall/winter)	342	29.0	29.0	0.8	0.8
Seasonal Storage (spring/summer)	345	12.0	41.0	0.3	1.1
Flood Control Storage					
- Fall/winter	373	307.0	336.0	8.5	9.3
- Spring/summer	373	295.0	336.0	8.2	9.3
Total	373	336.0	336.0	9.3	9.3

c. Outlets:

Type of Outlet	No. & Size	Invert Elev. (ft msl)	Opening Size & Control	Max. Discharge (cfs) at Top Cons.	Max. Discharge (cfs) at Top Flood
Flood conduits	7-6'x 7.5'	314.9	6'x 7.5' slide gates(1)	12,600	17,300
Low-flow conduits	2-5'x 5'	317.5	5' horizontal cylinder valves(2)	1,220	1,770

Notes:

(1) These gates are intended to operate in the fully open position and, in conjunction with the two horizontal cylinder valves, will permit regulation of the discharge in increments of about 600 cfs without operating the slide gates in a partially open position. A single tractor gate designed to travel in slots along the face of the dam and be operated by a gantry crane will make emergency closure of any one of the seven conduits.

(2) The horizontal cylinder (Howell-Bunger) valves are electrically operated and can be operated at any desired opening. Emergency control is by hydraulically operated slide gates with further provisions for closure by a bulkhead gate on the upstream face of the dam.

d. Hydropower category: Two penstocks were included in the dam for a future power option.

4. Water Management Criteria:

a. Authorized project purposes: Flood control, with an option for future power.

b. Water use contracts: One water supply contract with the city of Plainview for storage to yield 100,000 gallons per day.

c. Interagency agreements: None

d. Informal commitments: An informal agreement exists between the Arkansas Game and Fish Commission (AG&FC) and the Corps of Engineers to manipulate the water level for fisheries management purposes when feasible. Accordingly the low flow regulation pla. provided that on or about 15 April each year the water level be allowed to rise to elevation 345 to stimulate fish spawning and increase survival of larval fishes. Beginning about 15 May the water level is lowered slowly for mosquito control and to provide a minimum downstream release until elevation 342 is reached about 1 October. Except for periods of high inflow, or during special operations, the level remains at 342 until 15 April the following year. In 1955, 1956, 1960, and 1978 at the request of the AG&FC the water level has been reduced drastically (10 feet or more) in the summer or early fall to allow for reseeding the exposed bottom with rye or sudan grass and sorghum to improve water clarity. The drawdown also allows for reduction of the rough fish population. AG&FC restocks the lake with sport fish the following spring.

e. System regulation objectives: Nimrod Lake is one unit in a group of existing reservoir and local protection projects operated with the objective of reducing flooding in the Arkansas River Valley. Although Fourche LaFave River is a comparatively small tributary, the reduction of its peak flows by Nimrod Dam will usually also result in a decrease of downstream flood heights on the Arkansas River. However, Nimrod's required releases are so small in comparison to the regulated releases from the larger storage lakes in Oklahoma, that they are not included in the overall McClellan-Kerr Arkansas River Navigation System regulation objectives.

5. Project Evaluation:

a. General: Table 1 summarizes water quality data obtained during the period 1974 through September 1980 upstream at Gravelly, within the lake (8 stations), and downstream near Nimrod and Bigelow. It contains mean values from 50 measurements taken at each location. The data indicate that certain constituents, such as turbidity, iron, and manganese, settle out in the lake. They become concentrated in the lower depths, from which they are released downstream. Nutrient concentrations do not change significantly in the lake or downstream, although the lake would be expected to act as a nutrient sink. Iron and manganese exceed the recommended levels in drinking water of 300 and 50 micrograms/liter, respectively, at all locations within the lake system.

b. Effects of impoundment on water stored:

(1) Positive effects: The Fourche LaFave River has high turbidity which is caused primarily by colloidal clay particles. Much of the suspended material washed into the lake settles out, and the colloidal turbidity is reduced somewhat by impoundment in Nimrod Lake. Thus the lake clarity is greater near the surface. Also, grass planted by the Arkansas Game and Fish Commission during major drawdowns (paragraph 4d) helps reduce turbidity and contributes to lake fertility. The lake reduces the amount of iron and manganese moving in the river. Fecal coliforms entering the lake from tributaries (primarily Porter Creek) during storm runoff die off in the lake. The impoundment reduces the velocity of flood waters, thus preventing further scouring. Observed water quality in and downstream from Nimrod Lake reveals no deviations from the Arkansas water quality standards.

(2) Negative effects: Nimrod Lake stratifies during the late summer and early fall. Measurements at depths of 4-12 feet have indicated dissolved oxygen concentrations exceeding 5 mg/l, but readings of 0.1-0.4 mg/l have been made at depths of 32-48 feet near the dam. When stratification breaks up in late fall, increased concentrations of dissolved iron and manganese are mixed throughout the impounded waters for a short period of time. Therefore, lake releases during this time may contain excessive levels of these metals. The decomposition of the grass and terrestrial vegetation inundated during flood storage operations or after major drawdowns may help deplete the dissolved oxygen in the lower depths of the lake in the early summer. The resulting reducing environment produces hydrogen sulfide. On one occasion, hydrogen sulfide was present in the releases from the dam in sufficient concentrations to have reportedly caused white painted cabins 1/2 mile away to turn black because of the reaction of the lead-based paint with the hydrogen sulfide gas. Periodically, strong odors have been present below the dam, and the hydrogen sulfide has caused extensive rusting of exposed metal on the dam and control building.

(3) Causes of negative effects: The geology of the area is the reason for the high colloidal turbidity as well as the iron and manganese levels. The hydrogen sulfide problem is one which needs more detailed study. It appears to be related to oxygen depletion brought about by decay of organic material, but oxygen depletion occurs at other lakes which do not have problems with excessive hydrogen sulfide. Nimrod Lake is somewhat different in that frequently a substantial amount of lakeshore is exposed in the early growing season, and terrestrial vegetation develops. This vegetation is then inundated by stored flood waters. Sulfides are normally formed from sulfates, but Nimrod Lake does not appear to have excessively high sulfates. Accordingly, the origin of the hydrogen sulfide has not been clearly established.

Stratification is a function of rising temperatures primarily, and water quality deterioration in the lower depths follows stratification. Some of the excessive turbidity is caused by agricultural and silvicultural land use in the watershed, some because of wind action on the large area of shallow water, and some because of the rooting action of bottom feeding fish, such as carp and buffalo.

Table 1

Nimrod Lake Project - WQ Data[1]

Parameter	Sample Location		
	Upstream[2]	Lake[3]	Downstream[4]
Turbidity (JTU)	27	16	23
Dissolved Oxygen (mg/l)	9	6.5[5]	8.5
Iron (ug/l)	1,800	732	1,025
Manganese (ug/l)	615	185	350
Fecal coliform (#/100ml)	570	7	13
Nitrates + nitrites (mg/l N)	.06	.08	.08
Phosphorus (mg/l)	0.03	0.03	0.03
pH (SU)	7.0	6.8	6.9
Sulfates (mg/l)	5.1	5.8	5.8

[1]Mean values of up to 50 measurements at each station.

[2]At Gravelly, Arkansas.

[3]At 8 stations on the lake.

[4]Near Nimrod and Bigelow, Arkansas.

[5]Average values of samples taken at depths of 4 to 12 feet.

The principal purpose of Nimrod Lake is flood control; however, the lake is used extensively for recreation. At the present time there are seven recreation areas on the lake with seven more identified for future development subject to cost sharing. There is very little development along the lake shoreline: however, at times of heavy rainfalls there is noticeable seepage and runoff from malfunctioning septic tanks on Porter Creek. Also, there is a potential source of industrial pollution from the Mountain Pine Pressure Treating Company at Plainview. This plant has its own closed treatment system but should be inspected periodically due to the problems associated with a breakdown or system malfunction. The city of Plainview discharges municipal wastes into Porter Creek, a tributary to Nimrod Lake. Perryville discharges into the Fourche LaFave River below Nimrod Lake.

c. Project effects on instream flows:

(1) General: Discharge-duration curves for the project inflows and releases as well as natural flows are shown on the inclosed exhibits, 1 through 3.

The three graphs presented in this report represent the durations of flow for mean daily inflows, mean daily releases, and mean daily flows for natural conditions. The curves plotted are not for the same period of record; however, some general conclusions can be made. First, comparing the mean daily inflows (period of record, January 1944 through May 1979) to the mean daily flows for natural conditions (period of record, October 1919 through September 1941), it is seen that the duration of flows are nearly equal for both pre and post project conditions. The maximum peak flows are relatively similar: 55,380 cfs to 44,000 cfs, and the differences in low flow durations are related inconsistencies involved in low flow estimates for natural conditions. Generally, the durations of flows are almost the same except when flows are less than 100 cfs. However, comparison of the mean daily releases to the natural flows shows a large reduction in peak flow: 44,000 cfs to 19,800 cfs. It can be seen in the upper part of the curve (500 cfs to 5,000 cfs) that releases run about a 4 - 6 percent longer duration than natural flows would. In the majority of the curve (500 cfs to 10 cfs), releases run about 5 percent shorter durations than natural flows would. Although not apparent in this curve, the minimum release from the reservoir is 5 cfs. Since April 1967, there have been only 22 days where releases were less than 5 cfs. This is the operational minimum release and only when there is flooding downstream are releases cut back to zero to reduce downstream flood heights as much as possible.

Mean daily flows for natural conditions were computed by one of the following:

(a) By distributing the run-off estimated from rainfall by means of a unit hydrograph derived for the area.

(b) By estimating from the daily flows of the Petit Jean River at Danville.

(c) By computing from daily stages at staff gage 1.2 miles downstream from the dam (5 March 1929 through 31 August 1932).

AD-A156 496 RESERVOIR CONTROL CENTER: ACTIVITIES AND ACCOMPLISHMENTS OF THE SOUTHWEST..(U) CORPS OF ENGINEERS DALLAS TX SOUTHWESTERN DIV JAN 81

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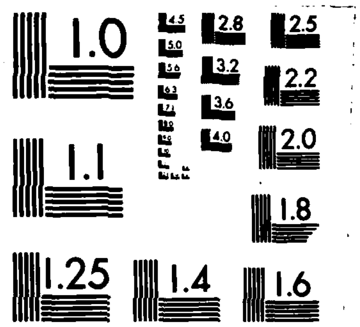
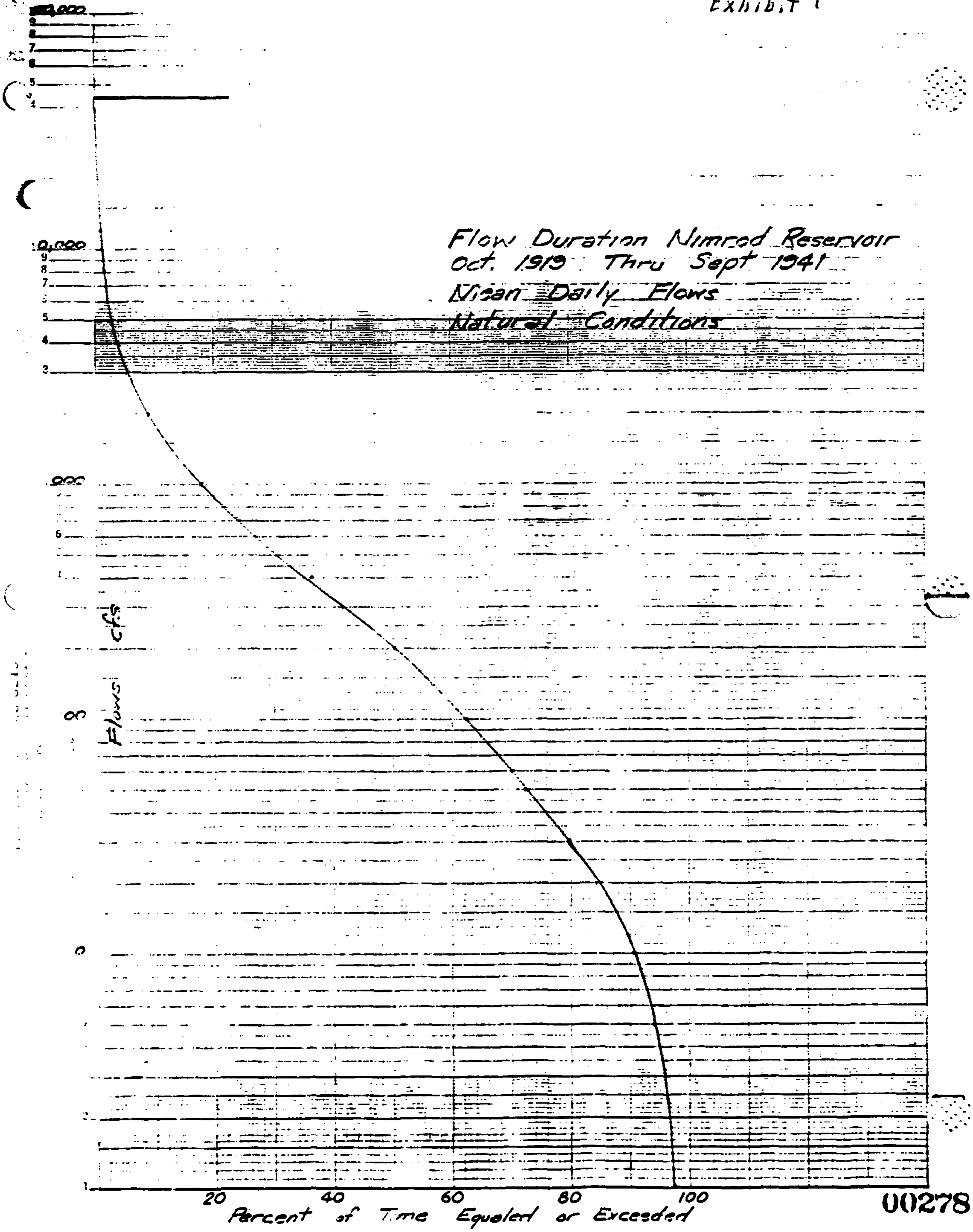


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Exhibit 1



00278

Exhibit 2

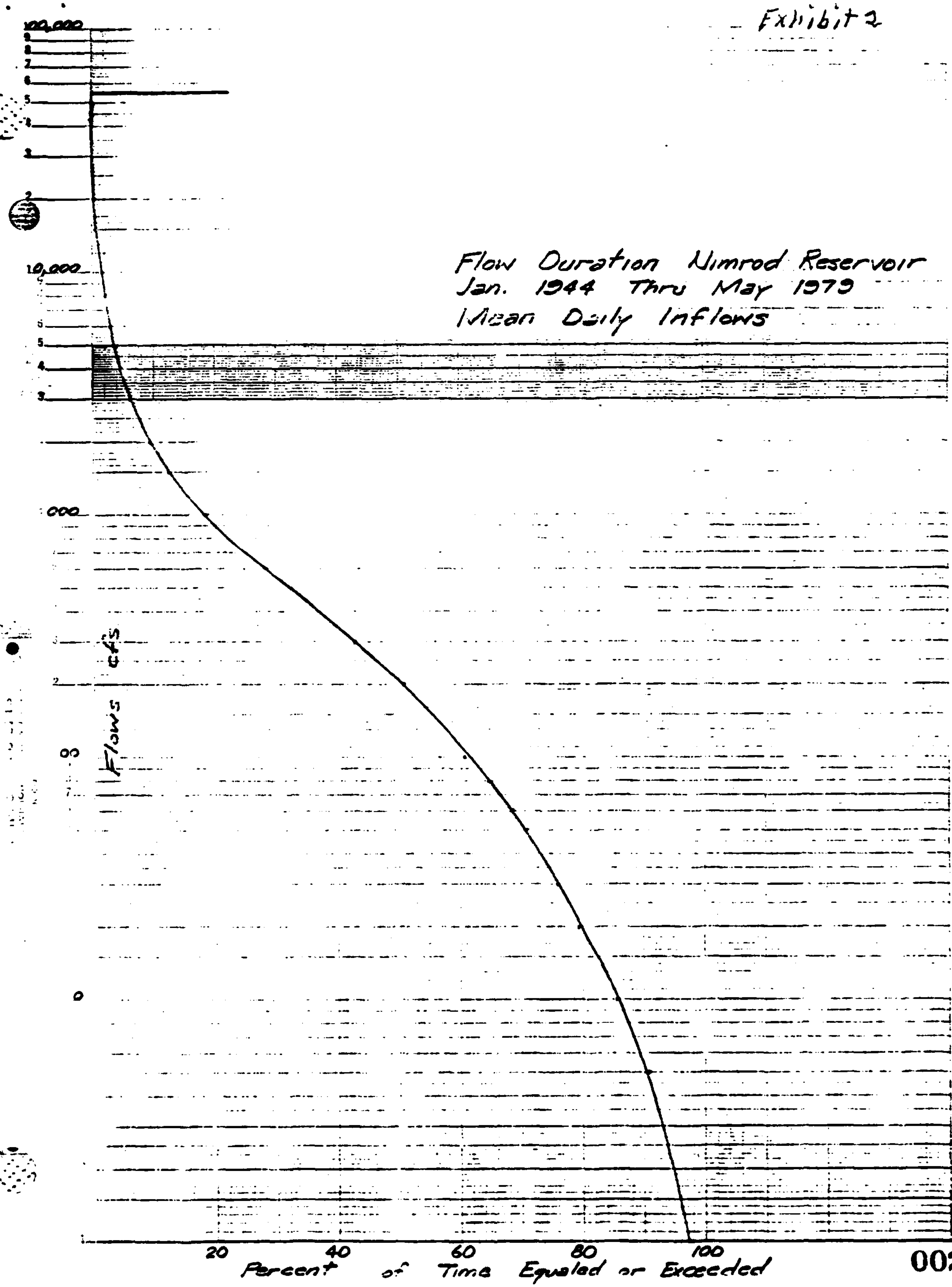

Flow Duration Nimrod Reservoir
Jan. 1944 Thru May 1979
Mean Daily Inflows
100,000
10,000
1,000
Flows cfs
20
40
60
80
100
Percent of Time Equaled or Exceeded

Exhibit 3

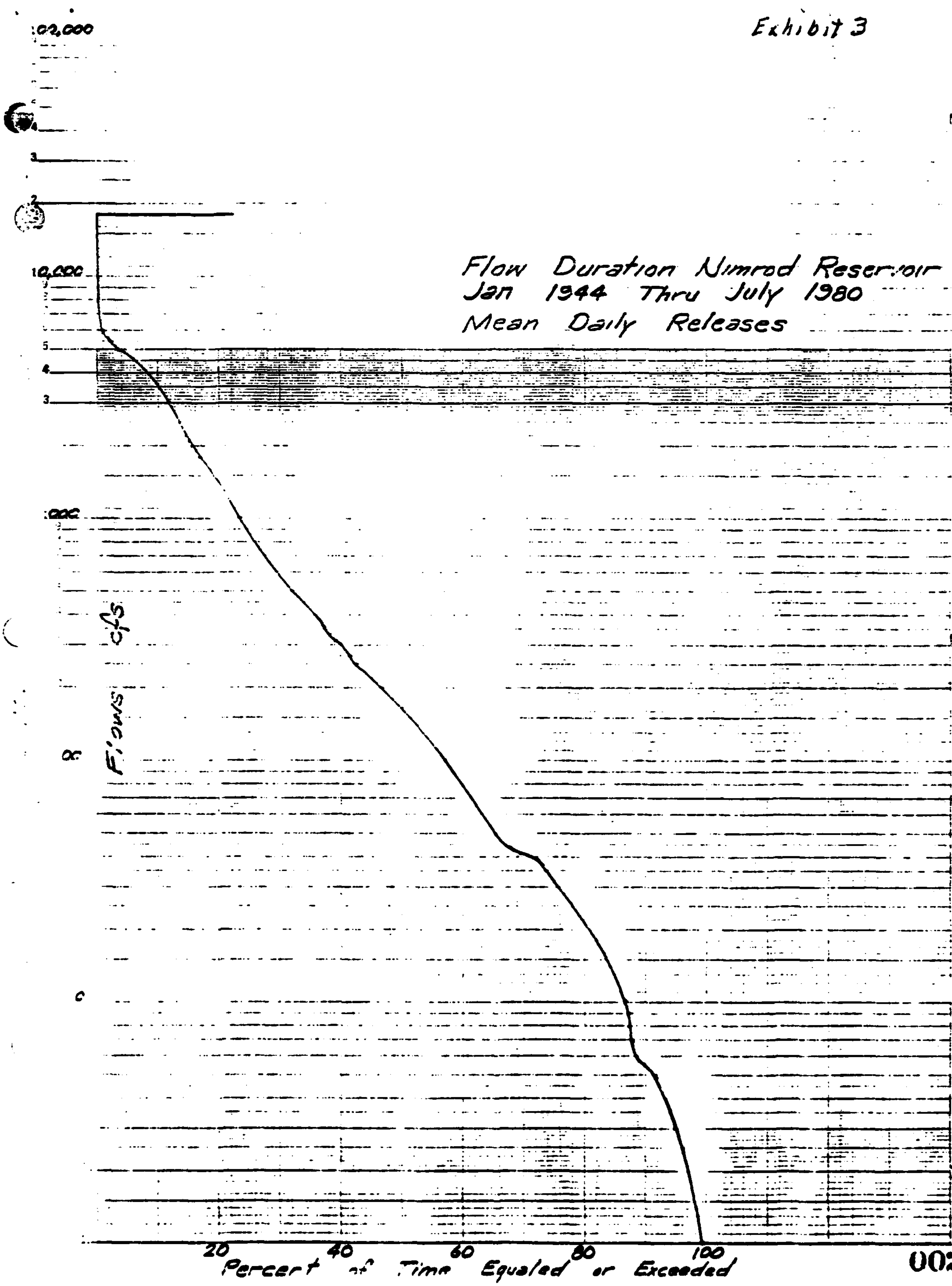
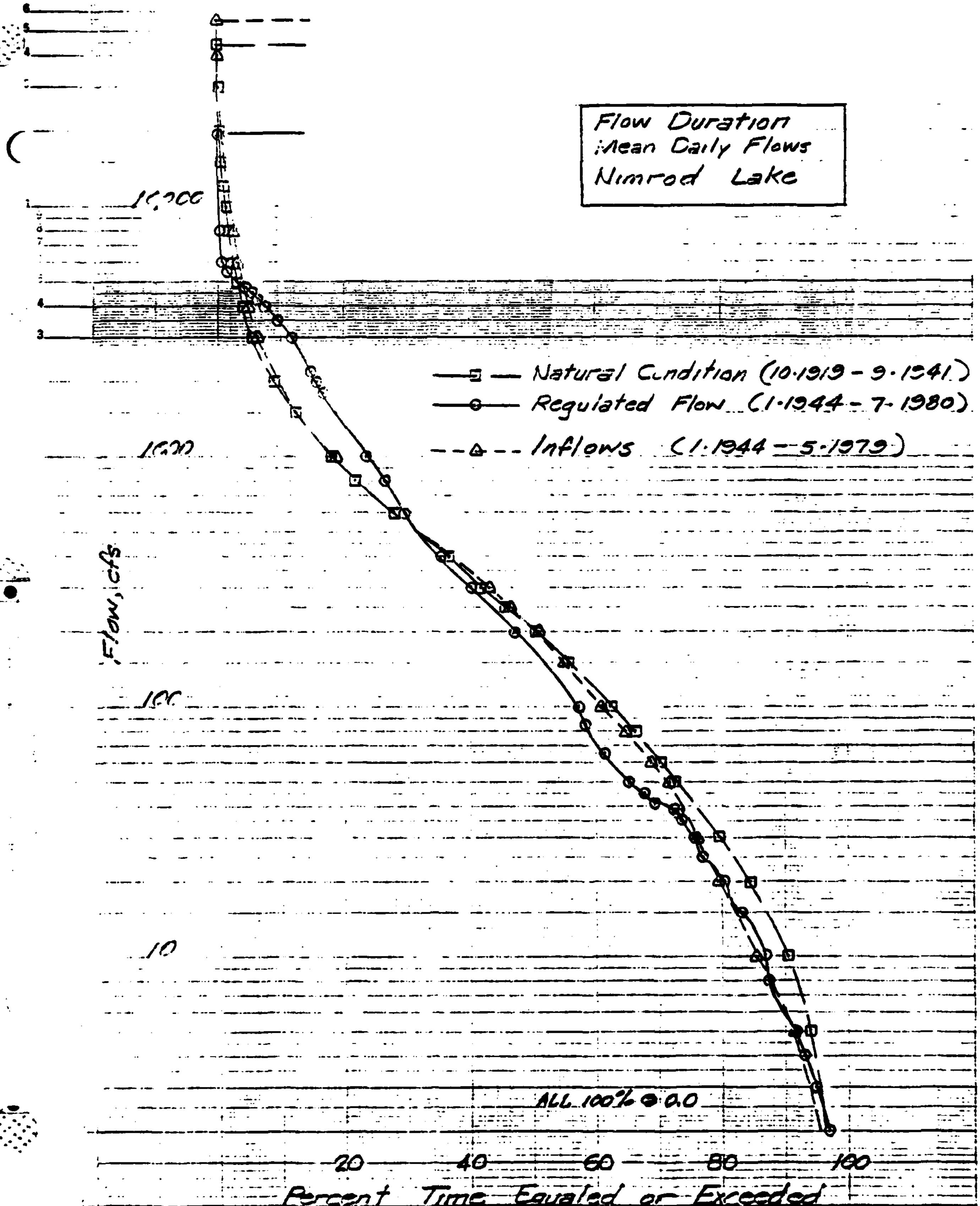

Flow Duration Nimrod Reservoir
Jan 1944 Thru July 1980
Mean Daily Releases
10,000
Flows cfs
20
40
60
80
100
Percent of Time Equaled or Exceeded

Exhibit 4



Combination of Exhibits 1, 2 & 3.

(2) Positive effects: The flood reduction features of the project reduce the high flows and increase the duration of flows around bank full discharges downstream of the dam. The low flow releases are normally significantly greater than preproject low flows, and the minimum release of 5 cfs is an improvement over natural minimum flows, which frequently were zero. The 5 cfs minimum release was established to replenish low flow pools downstream in the Fourche LaFave River for fishery purposes. The iron and manganese concentrations at the downstream sampling locations average more than in the lake but are less than the concentrations measured upstream of the dam. The fecal coliform levels in the releases are significantly less than in the inflows to the project.

The low flow release conduits utilize Howell-Bunger valves, which help aerate the releases and strip out objectionable gases such as hydrogen sulfide.

(3) Negative effects: The water discharged downstream sometimes appears more turbid than the lake surface water because of stratification and density currents within the lake. During the lake turnover period, excessive levels of iron and manganese are present in the outflow. As discussed earlier, there are occasional high levels of hydrogen sulfide in the releases. These normally occur when flood waters are being released.

(4) Cause of negative effects: The turbidity of the downstream releases is related to the level in the lake from which the water is withdrawn and thus is due to the outlet configuration. The increase in iron and manganese concentrations during turnover is due to the circulation from the lake bottom of waters with significantly higher amounts of those metals. The possible cause of the occasional hydrogen sulfide problem has been discussed previously.

d. Project effect on system regulation:

(1) Nimord is regulated independently from the upstream flood control reservoirs in the McClellan-Kerr Arkansas River Navigation System. In general, its regulated releases have little or no effect on Arkansas River flood flows and no recognized negative effects on quality or quantity.

(2) These regulated releases may have positive effects on the quantity of Arkansas River flows when stored floodwater is being evacuated coincidently with marginal navigation taper flows and thereby can supplement minimal releases from the upstream reservoirs. They may have a positive effect on quality on rare occasions when such releases may coincide with extremely low flows on the Arkansas River and thereby dilute the salt content in the Arkansas River water.

6. Constraints on Obtaining Instream Quantity and Quality Objectives:

a. Quantity: The present minimum low flow release is 5 cfs; however, in most years, releases required to gradually lower the 3-foot seasonal raise in the conservation pool between 15 May and 30 September are several times the minimum. This regulation plan is generally consistent with the recommendations of fishery biologists to provide stable releases during the spring and early summer months. In dry years with near zero inflows, the

5 cfs minimum release may be less than desired by fishery biologists or downstream water users; e.g., rice farmers who want to irrigate with the water released, but they are more than would have occurred if the impoundment had not been constructed.

b. Quality: The desire to minimize the adverse effects of occasional low dissolved oxygen and high hydrogen sulfide levels in the releases has led to recommendations that may conflict with normal operating procedures. For example, one recommendation was to prolong flood water drawdowns over a period of several weeks.

An apparent tradeoff exists between fishery management within the lake and the quality of the releases. As mentioned earlier, grass is planted during major drawdowns to increase fertility in the lake and help clear the water. This practice, however, may contribute to degraded releases (hydrogen sulfide) for a temporary period of time.

7. Alternatives:

a. Reservoir regulation: The present regulation plan is considered adequate for downstream quantity needs, although deviations are made occasionally to accommodate downstream users.

b. Structural modification: It is probable that the problem of excessive hydrogen sulfide in the releases could be alleviated by the construction of a multilevel intake. This would allow release of water from closer to the surface, thus avoiding the higher concentrations of hydrogen sulfide near the bottom, especially during the turnover.

c. Storage reallocation: NA

d. Other: Previous major drawdowns have resulted in reduction in turbidity within the lake, evidently due to the drying out and "solidification" of the exposed lake bottom, the removal of large rough fish (bottom feeders), and the planting of rye grass on this exposed area. The decomposition of the grass provides the carbon dioxide necessary to flocculate the colloidal clays which inflow adds to the lake constantly. This practice is expected to be continued on a periodic basis to reduce turbidity and for fishery management purposes.

8. Actions Taken to Date: Major drawdowns for fishery management purposes were conducted in 1955, 1956, 1960, and 1978, at the request of the Arkansas Game and Fish Commission. The drawdowns, which were coordinated with other fishery management techniques, were considered successful.

9. Planned Actions: A water quality study is proposed to determine the feasibility of various methods of avoiding the discharge of excessive hydrogen sulfide. This study would cost approximately $35,000 and would take 18 months to complete. It would involve coordination with the Arkansas Game and Fish Commission, the Environmental Protection Agency, and the U.S. Fish and Wildlife Service. Unless supplemental funds were available, this study could not be budgeted for earlier than FY 83.

1. Project Name: Lake Kemp

2. Project Location: River Mile 126.7 on Wichita River tributary to Red River. Project watershed (2,086 square miles) located in Texas; downstream management control stations located in Texas.

3. Type of Project:

a. General Category: Multiple-purpose storage reservoir (excluding hydropower)

b. Storage Allocations:

	Elevation Feet (N.G.V.D.)	Storage Acre-Feet	Storage Inches Runoff
Top Flood Control Pool	1156.0	502,900	4.52
Top Conservation Pool	1144.0	268,000	2.41
Bottom Conservation Pool		0	

4. Water Management Criteria:

a. Authorized Project Purpose: Flood control and conservation.

b. Water Use Contracts: None

c. Interagency Agreements: None

d. Informal Commitments: None

e. System Regulation Objectives: None

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long term basis, the lake decreases nitrates, phosphates, and heavy metals in the stream.

(2) Negative effects: None known.

b. Project Effect on Instream Flows:

(1) General: Discharge frequency and duration curves for modified and natural conditions are attached.

(2) Positive effects: Peak flow magnitudes have been reduced.

(3) Negative effects: None known.

c. Project Effects on System Regulation: The project has a major flood controlling capability on the Wichita River but an insignificant effect on the Red River.

6. Alternatives:

a. Reservoir Regulation: None

b. Structural Modification: None

c. Storage Reallocation: None

d. Other: No action

7. Action Taken To Date: None

8. Planned Action: None

LAKE KEMP
WICHITA RIVER, TEXAS

Top of Conservation (Power) Pool Elevation	1144
Top of Flood Control Pool Elevation	1156

OUTLET WORKS

Type	Conduit
Size	13' Dia.
Intake Elevation	1090
Control Gates	2-5.67'x13'
Capacity at Conservation Pool (c.f.s.)	6200
Capacity at Flood Control Pool (c.f.s.)	6800

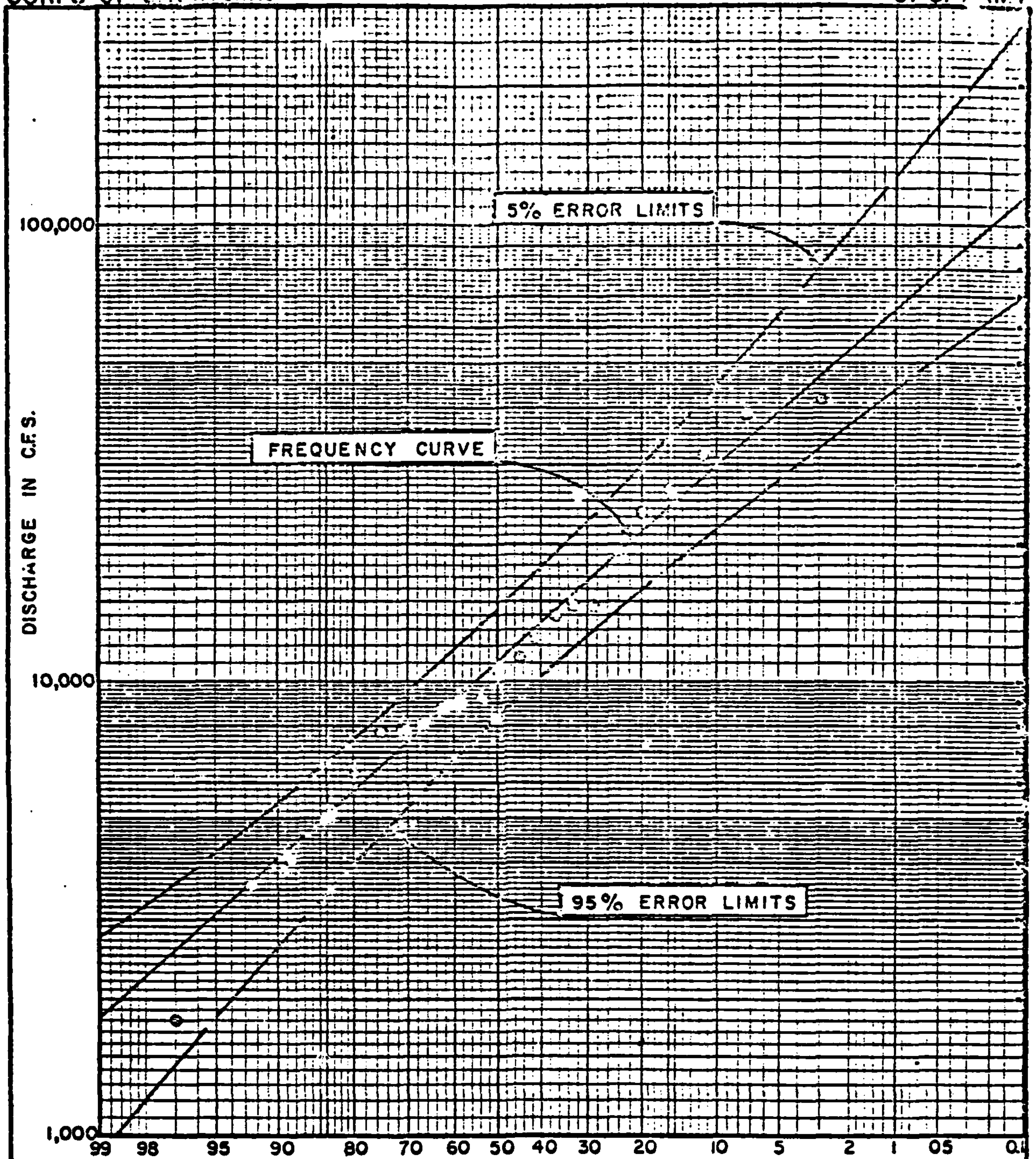
WATER SUPPLY FACILITY

Low Flow	
Type	Pipe
Size	6" Dia.
Elevation	1093.75
Capacity at Conservation Pool (c.f.s.)	6

SPILLWAY

Type	Excav
Crest Width	3,000
Crest Elevation	1160
Control	Uncon
Capacity at Conservation Pool (c.f.s.)	0
Capacity at Flood Control Pool (c.f.s.)	0

CORPS OF ENGINEERS U. S. ARMY



NOTE:

BASIC DATA ARE ESTIMATED PEAK DISCHARGES AT THE DAM SITE FROM JANUARY 1940 THROUGH SEPTEMBER 1962.

LAKE KEMP
WICHITA RIVER, TEXAS

FREQUENCY CURVE OF ANNUAL FLOOD PEAKS

U. S. ARMY ENGINEER DIST., TULSA, CORPS OF ENGINEERS JUNE 64
DRAWN: L.R.D.
CHECKED: J.L.R.

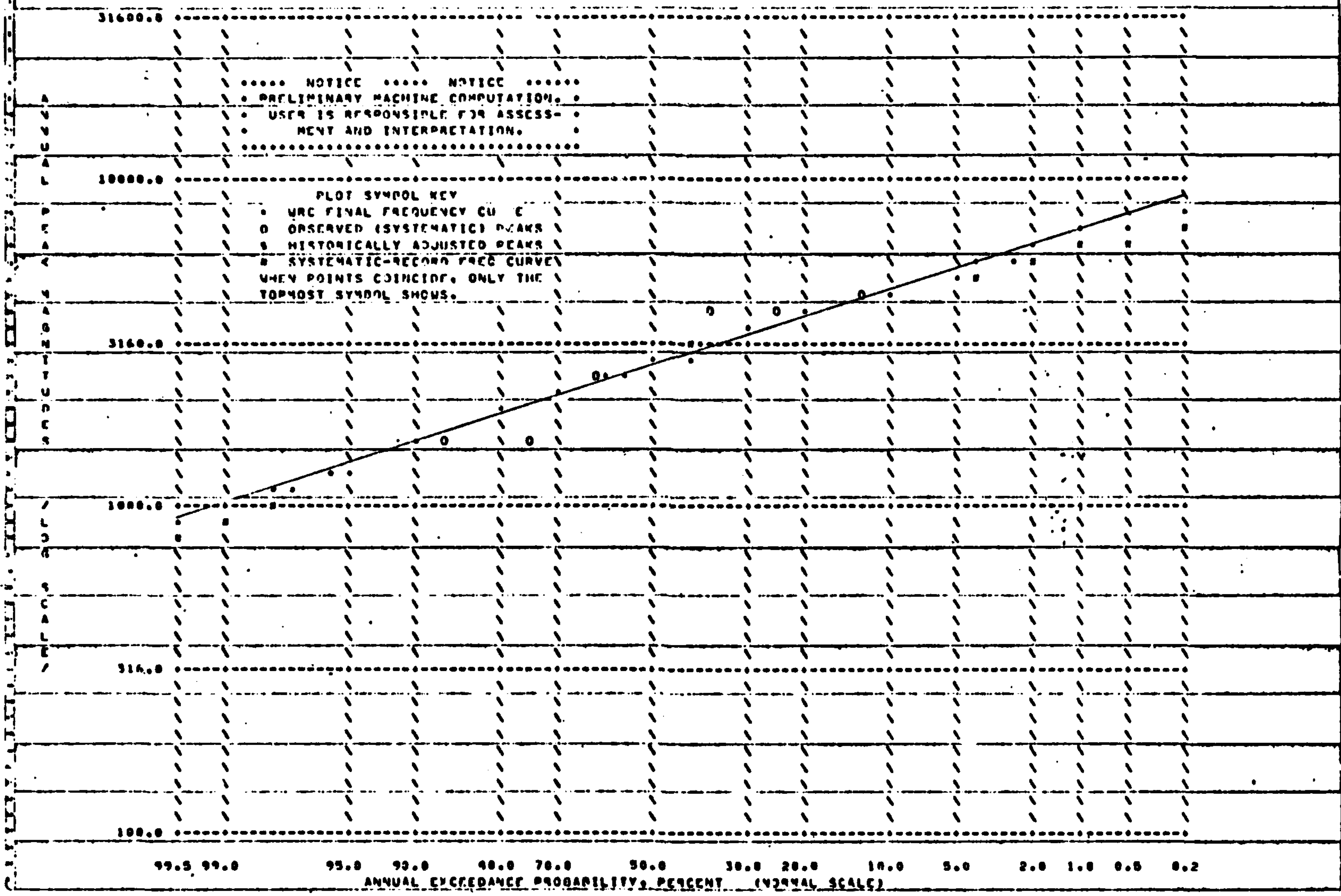
LAKE KEMP

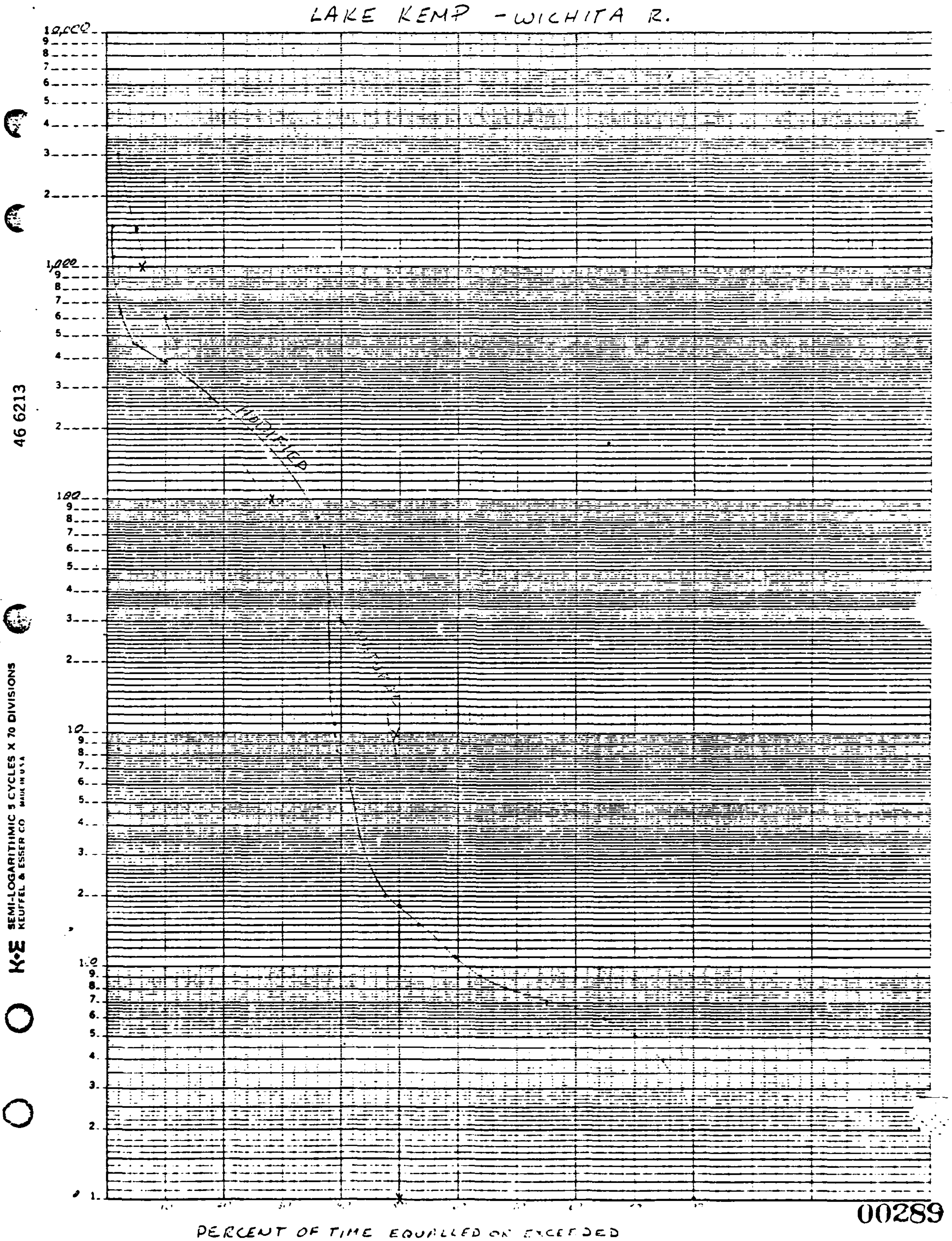
J407 VER 3.4
V 10/22/79)

U. S. GEOLOGICAL
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 3/80 AT 1533 SEQ 1.0001

STATION - 07312100/USGS WICHITA RIVER NR MABELLE, TEX. 1973-1979 07312100/USGS





LAKE KEMP - WICHITA R.
MODIFIED
PERCENT OF TIME EQUALLED OR EXCEEDED
46 6213
K•E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

00289

1. Project Name: Waurika Lake

2. Project Location: River mile 27 on Beaver Creek tributary to Red River. Project watershed (562 square miles) located in Oklahoma; downstream management control stations located in Oklahoma and Texas.

3. Type of Project:

a. General Category: Multiple-purpose storage reservoir (excluding hydro-power)

b. Storage Allocations:

	Elevation (feet N.G.V.D.)	Storage Acre-Feet	Storage Inches of Runoff
Top Flood Control Pool	962.5	343,500	11.45
Top Conservation Pool	951.4	203,100	6.78
Bottom Conservation Pool	910.0	3,400	.11
Water Supply Storage (36.2 mgd)		154,000	
Water Quality (Interim W.S. Use)			

4. Water Management Criteria:

a. Authorized Project Purpose: flood control, water supply, water quality, recreation, fish and wildlife and irrigation.

b. Water Use Contracts: Water storage 36.2 mgd

c. Interagency Agreements: Minimum release schedule with EPA for Cache and Cow Creek via water supply pipeline.

d. Informal Commitments: None

e. System Regulation Objectives: None

5. Project Evaluation:

a. Effects of impoundment on water stored:

1. Positive effects:

a. Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

b. Quantity: The lake provides storage for flow augmentation in times of drought.

2. Negative effects:

a. Quality: Waurika Lake becomes thermally stratified from early summer through mid-fall. Chemical reactions within the anoxic hypolmnion cause an increase in dissolved iron and manganese within this zone. The water in the hypolimnion decreases in pH and temperature, and ammonia and hydrogen sulfide levels are elevated. When the lake returns to complete mixing in the fall, the water quality becomes more desirable.

b. Quantity: Flood control operations cause tailwater fluctuations to be greater than normal.

3. Cause of negative effects: Soils within the watershed are high in iron and manganese. Agricultural operations lead to large input of these soils to the lake.

6. <u>Project Effect on Instream Flows</u>:

1. <u>General</u>: Natural discharge frequency and duration curves are attached. A predicted duration curve for the modified condition is also included.

2. <u>Positive effects</u>: Flow augmentation is possible for Cache and Cow Creeks.

3. <u>Negative effects</u>: Historical data from Waurika tailwater stations were compared to Oklahoma Raw Water Supply Standards (see attachments). These drinking water standards were used because Oklahoma has few numerical standards for other water classes. Few violations of any parameters were noted. This is no doubt due to the selective withdrawal capability of the outlet works.

4. <u>Project effects on system regulation</u>: The project has minimal effects on the Red River system.

7. <u>Constraints on Obtaining Instream Quantity and Quality Objectives</u>: Capacity of multilevel intakes is insufficient to satisfy temperature objectives during flood releases. Release quality of low flow requirements on Cache and Cow Creeks are dependent on pumped water supply water in pipelines.

8. <u>Alternatives</u>:

a. <u>Reservoir Regulation</u>: None

b. <u>Structural Modification</u>: None

c. <u>Storage Reallocation</u>: None

d. <u>Other:</u> No action

8. <u>Action Taken to Date</u>: None

9. <u>Planned Action</u>: None

WAURIKA
BEAVER CREEK, OKLAHOMA

Top of Conservation (Power) Pool Elevation	951.4
Top of Flood Control Pool Elevation	962.5

OUTLET WORKS

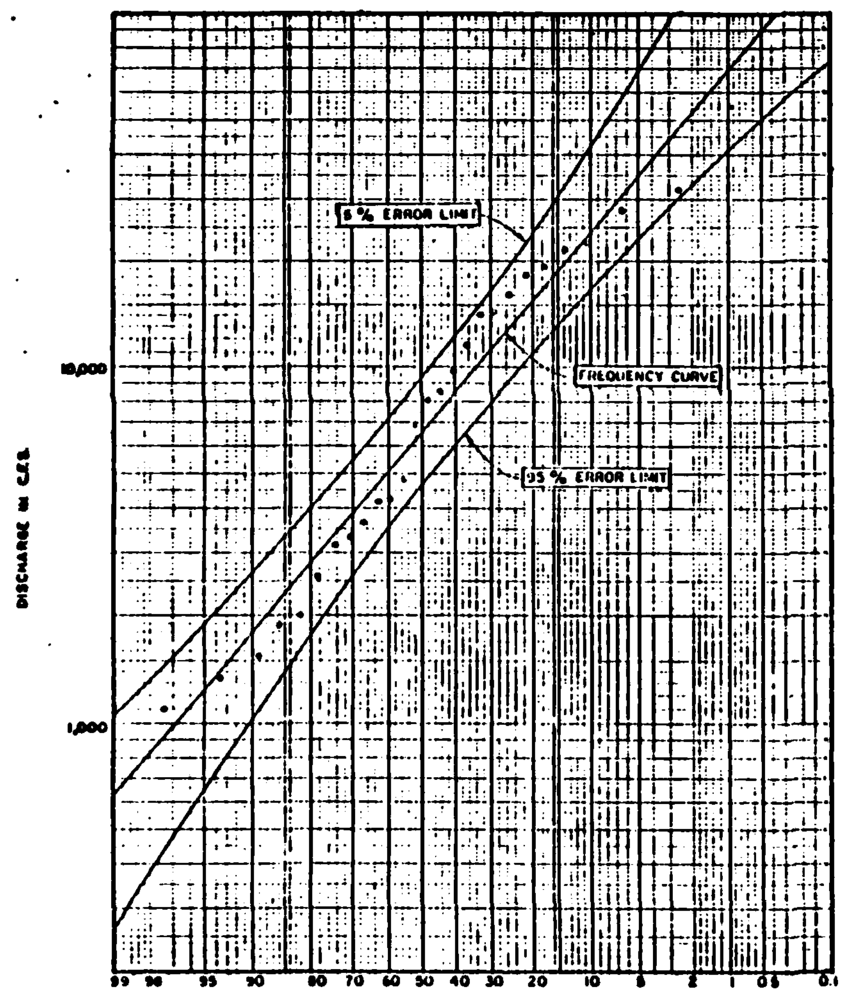
Type	Conduit
Size	11'x15.5'
Intake Elevation	893.0
Control Gates	2-5.5'x13.5'
Capacity at Conservation Pool (c.f.s.)	5550
Capacity at Flood Control Pool (c.f.s.)	6100

WATER SUPPLY FACILITY

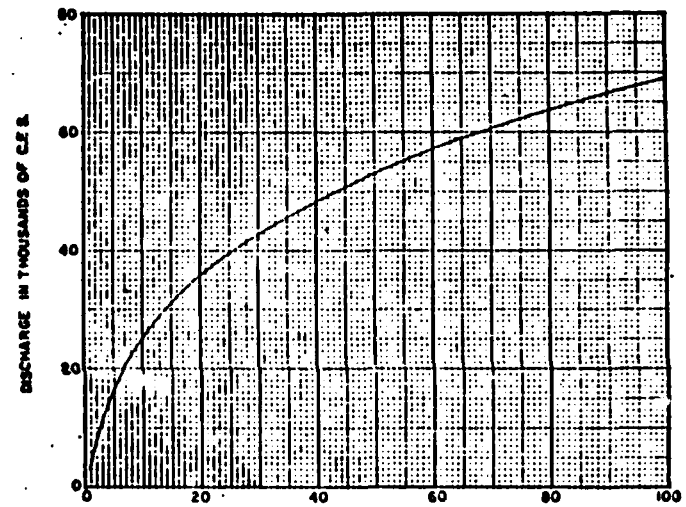
Low Flow	
Type	Pipe
Size	12" Dia.
Elevation	907.0
Capacity at Conservation Pool (c.f.s.)	28
Static Head Pipe	
Diameter	14" Dia.
Elevation	891.26

SPILLWAY

Type	Excavated
Crest Width	300'
Crest Elevation	970.0
Control	Uncontrolled
Capacity at Conservation Pool (c.f.s.)	0
Capacity at Flood Control Pool (c.f.s.)	0



CUMULATIVE FREQUENCY CURVE OF ANNUAL PEAK FLOWS



DISCHARGE PROBABILITY UNDER NATURAL CONDITIONS.

NOTES:

1. BASED ON METHODS OUTLINED IN "STATISTICAL METHODS IN HYDROLOGY" LEO R. BEARD, JAN. 1962
2. BASIC DATA ARE COMPUTED ANNUAL PEAK DISCHARGES AT THE DAM SITE FROM OCTOBER 1938 THROUGH SEPTEMBER 1964

WAURIKA RESERVOIR

BEAVER CREEK, OKLAHOMA

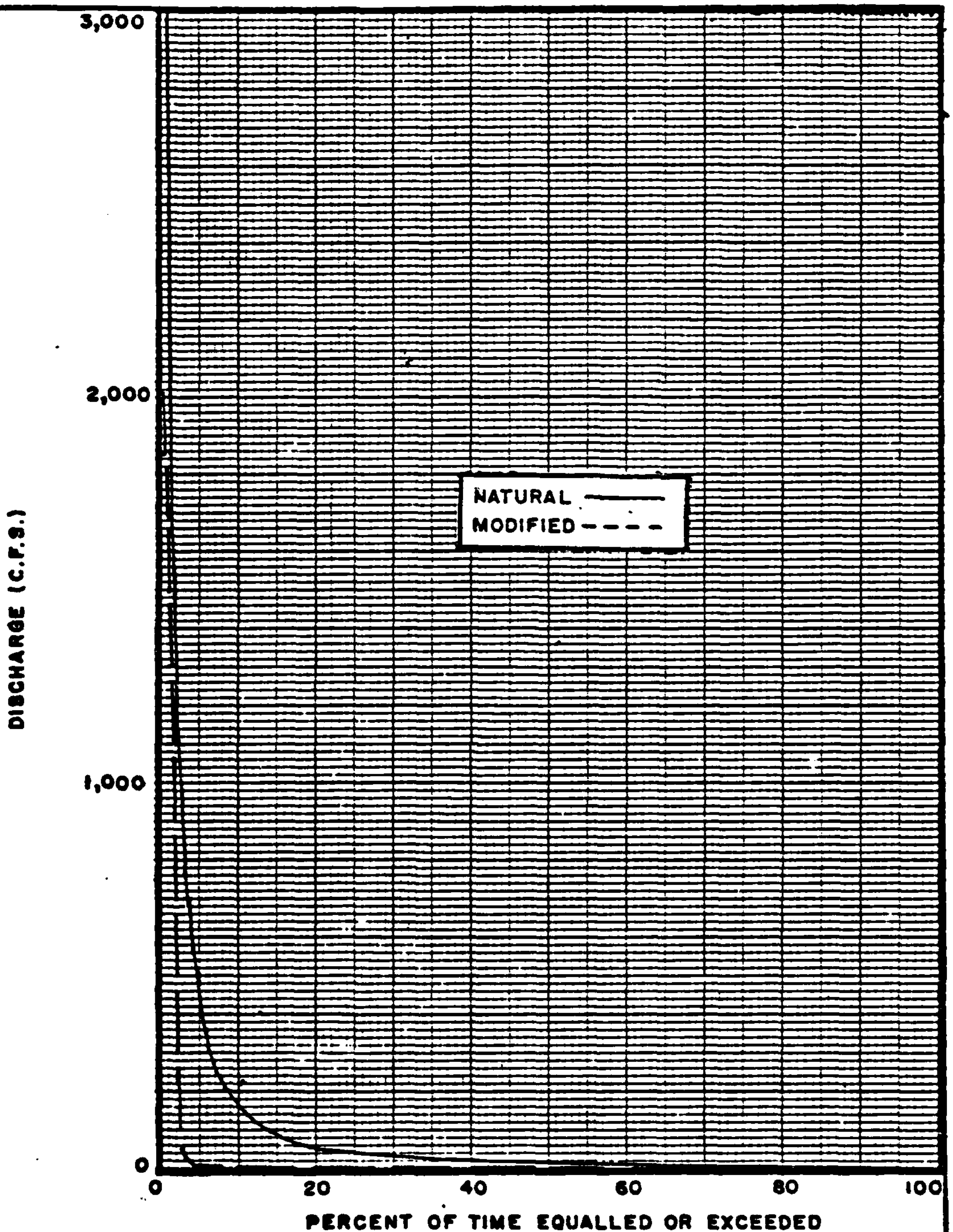
PEAK DISCHARGE FREQUENCY CURVES

U.S. ARMY ENGINEER DIST., TULSA, CORPS OF E[illegible]

DRAWN: T.U.T.

CHECKED: B.B.B

1440-[illegible]-99/8



RED RIVER WATERSHED BEAVER CREEK, OKLAHOMA

WAURIKA LAKE

FLOW DURATION CURVE FOR ULTIMATE PROJECT AT DAM SITE

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1973
DRAWN: J. Z. D.
CHECKED: T. W.

60294

STORET R[illegible]EVAL DATE 80/10/10 - STAND - VERSION OF SEP. 198[illegible]
WQ DATA [illegible] MILES BELOW WAURIKA

STN 1.SUMMARY.1

07313500
34 13 30.0 098 02 57.0 2
BEAVER CREEK NR WAURIKA, OK
40067 OKLAHOMA JEFFERSON
101591

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 77/09/21 TO 79/10/01

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	15	0	2	0	2	2	2	13	12	0
MEAN	16.04	0.0	2.50	0.	1.000	18.50	4.	6.200	0.580	0.0
MEDIAN	15.60	0.0	2.50	0.	1.000	18.50	4.	6.100	0.400	0.0
NO OF VIOLS	0	0	0	0	0	0	0	4	1	0
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	31.	8.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	1.500	2.600	0.0
MEAN VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	3.425	2.600	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	5.000	2.600	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

WQ DATA 1.2 MILES BELOW WAURIKA

07313500
34 13 00.0 098 02 57.0 2
BEAVER CREEK NR WAURIKA, OK
40067 OKLAHOMA JEFFERSON
101591

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 77/09/21 TO 79/10/01

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	2	0	2	0	13	13	2	2	2	6
MEAN	16.50	0.0	0.500	0.0	7.615	7.615	1.000	2.00	16.	46.47
MEDIAN	16.50	0.0	0.500	0.0	7.700	7.700	1.000	2.00	16.	45.50
NO OF VIOLS	0	0	0	0	0	0	0	0	0	3
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	0.	0.	50.
MINIMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	74.00
MEAN VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	84.33
MAXIMUM VIOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	100.00
MIN CRITERIA	*********	*********	*********	*********	*********	6.500	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	9.000	*********	10.000	50.00	5000.	50.00

0029

STORET EVAL DATE 80/10/10 - STAND - VERSION OF SEP. 19 STN 2.SUMMARY.1
WQ DATA ... MILES BELOW WAURIKA

112000A9X112301 07313500
34 13 00.0 098 02 57.0 2
BEAVER CREEK NEAR WAURIKA
40067 OKLAHOMA
RED RIVER 1015
RED RIVER
210KOSHD
0000 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 77/08/30 TO 80/08/05

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	23	0	4	0	5	5	5	23	19	0
MEAN	14.89	0.0	7.00	0.	1.400	14.20	9.	6.204	0.601	0.0
MEDIAN	14.50	0.0	6.50	0.	1.000	16.00	6.	6.100	0.440	0.0
NO OF VIOLS	0	0	0	0	0	0	0	8	1	0
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	35.	5.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	1.500	2.600	0.0
MEAN VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	3.012	2.600	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	4.500	2.600	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

00297

STORET RETRIEVAL DATE 80/10/10 - STAND - VERSION OF SEP. 1980 STN 2.SUMMARY.2
WQ DATA 1.2 MILES BELOW WAURIKA

11200DA9X112301 07313500
34 13 00.0 098 02 57.0 2
BEAVER CREEK NEAR WAURIKA
40067 OKLAHOMA
RED RIVER 1015
RED RIVER
210KOSHD
0000 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 77/08/30 TO 80/08/05

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	5	0	5	0	23	23	4	5	5	24
MEAN	18.40	0.0	0.540	0.0	7.557	7.557	3.000	2.60	36.	44.34
MEDIAN	20.00	0.0	0.500	0.0	7.700	7.700	3.000	3.00	18.	16.00
NO OF VIOLS	0	0	0	0	0	1	0	0	0	9
PERCENT VIOL	0.	0.	0.	0.	0.	4.	0.	0.	0.	38.
MINIMUM VIOL	0.0	0.0	0.0	0.0	0.0	5.600	0.0	0.0	0.	59.00
MEAN VIOL	0.0	0.0	0.0	0.0	0.0	5.600	0.0	0.0	0.	99.33
MAXIMUM VIOL	0.0	0.0	0.0	0.0	0.0	5.600	0.0	0.0	0.	200.00
MIN CRITERIA	*********	*********	*********	*********	*********	6.500	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	9.000	*********	10.000	50.00	5000.	50.00

1. Project Name: Texoma Lake (Denison)

2. Project Location: River mile 725.9 on Red River tributary to Mississippi River. Project watershed (39,719 square miles) located in Oklahoma and Texas; downstream management control stations located in Texas, Oklahoma and Arkansas.

3. Type of Project:

a. General category: Multiple-purpose storage reservoir (including hydropower).

b. Storage allocations:

	Elevation (feet) (N.G.V.D.)	Storage Acre Acre-feet	Storage Inches Runoff
Top Flood Control Pool	640.0	5,312,300	2.51
Top Conservation Pool	617.0	2,643,300	1.25
Bottom Conservation Pool	590.0	1,031,300	.49
Water Supply Storage (31.1 mgd)		50,000	

c. Hydropower category: peak demand

4. Water Management Criteria:

a. Authorized project purpose: flood control, water supply, navigation, hydropower, and low flow augmentation

b. Water use contracts: Existing water storage - 21.8 mgd; pending water storage - 8.8 mgd; existing water withdrawal - 0.5 mgd; and pending water withdrawal - 0.01 mgd.

c. Interagency agreements: Southwestern Power Administration markets the power.

d. Informal commitments: March of Dimes canoe race in late April each year.

e. System regulation objectives: Optimize flood control and other water resource benefits downstream. Operated in conjunction with Hugo and Millwood (Little River System) for lower Red River.

5. Project Evaluation:

a. Effects of impoundment on water stored:

(1) Positive effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(b) Quantity: The lake provides storage for flow augmentation in times of drought.

(2) Negative effects:

(a) Quality: Lake Texoma becomes thermally stratified from early summer through mid-fall. Due to differences in dissolved solids content of the principle feeder rivers, various parts of the lake stratify by density. Chemical reactions within the anoxic hypolimnion cause an increase in dissolved iron and manganese within this zone. The water in the hypolimnion decreases in pH and ammonia and hydrogen sulfide levels are elevated. When the lake returns to complete mixing in the fall, water quality becomes more desirable.

(b) Quantity: Power generation causes tailwater fluctuations to be greater than normal.

(3) Cause of negative effects: Soils within the watershed are high in iron and manganese. Agricultural operations lead to large input of these soils to the lake. Additionally, the Red River contains high levels of total dissolved solids which lead to the formation of haloclines.

6. <u>Project Effect on Instream Flows</u>:

(1) General: Discharge frequency and duration curves for the natural and modified conditions are attached. The project is being studied for possible additional hydropower units and storage reallocation.

(2) Positive effects: Reductions in peak flow magnitudes have been observed since project completion.

(3) Negative effects: Historical data from Texoma tailwater stations were compared to Oklahoma Raw Water Supply Standards (See Attachments). These drinking water standards were used because Oklahoma has few numerical standards for other water classes. The only problem area found was dissolved oxygen levels. Approximately 25 percent of the samples contained less than 5 ppm dissolved oxygen. Few violations of other parameters were noted.

(4) Cause of negative effects: Water withdraw from the hypolimnion for power generation is anoxic. Turbulence from the release is insufficient to allow this water to meet State standards for dissolved oxygen until it travels several miles downstream.

(5) Project effects on system regulations: The project has a major effect on flood control capabilities of the Red River system. Releases made for power significantly contributes to the daily flow of the Red River.

7. <u>Constraints on Obtaining Instream Quantity and Quality Objectives</u>: All discharge water comes from bottom of lake. Due to outlet size small discharges are difficult to make (actual release c.f.s. is questionable). No storage is authorized for water quality releases.

8. Alternatives:

a. Reservoir regulation: A 50 cfs release made through the flood control conduit during the period of low dissolved oxygen power releases (mid-June to mid-September) would improve the fish habitat in the basin.

b. Structural modification: Ability to withdraw surface water for generation would improve the downstream quality of releases. A structural modification is required to make such withdraws.

c. Storage reallocation: If a 50 cfs release was to become part of the project regulation, reallocation would be necessary.

d. Other: Oxygen injection in the hypolimnion or destratification of the main lake body would improve release water quality.

e. No action.

9. Action Taken to Date: A study was conducted to determine the dissolved oxygen content of conduit releases. Extensive data collection was conducted to document the release water quality.

10. Planned Action: Studies of release water quality and of effects of a low flow release of 50 cfs are planned.

TEXOMA (DENISON)
RED RIVER, OKLAHOMA AND TEXAS

Top of Conservation (Power) Pool Elevation		617.0 (Power)
Top of Flood Control Pool Elevation		640.0

OUTLET WORKS

Type	Penstock	Conduit
Size	5-20' Dia.	3-20' Dia.
Intake Elevation	532.0	532.0
Control Gates	10-9'x19'	6-9'x19'
Capacity at Conservation Pool (c.f.s.)		60,120
Capacity at Flood Control Pool (c.f.s.)		67,500

SPILLWAY

Type	Chute
Crest Width	2000'
Crest Elevation	640.0
Control	Uncontrolled
Capacity at Conservation Pool (c.f.s.)	0
Capacity at Flood Control Pool (c.f.s.)	0

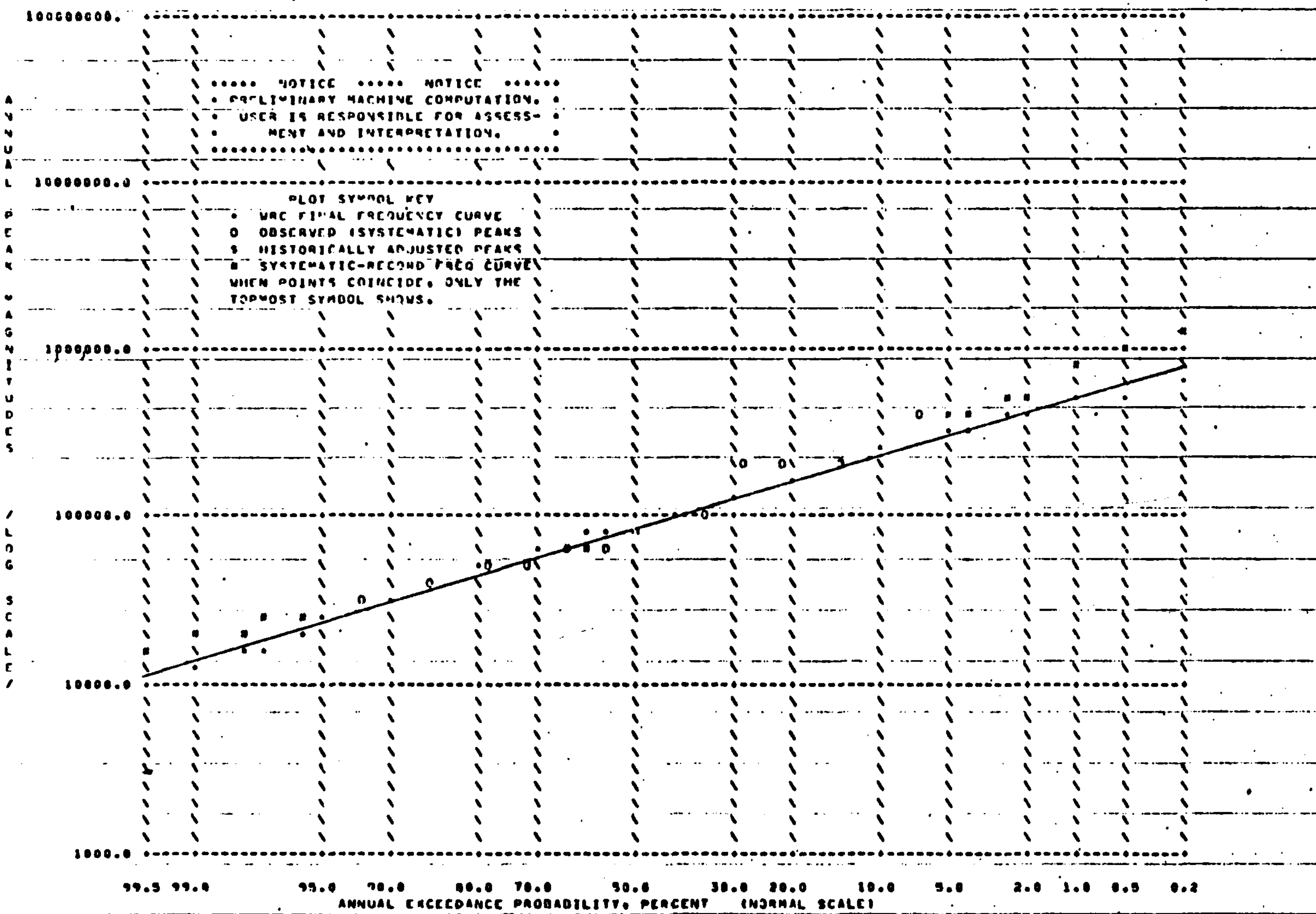
TEXOMA - ORII

J407 VER 3.4 10/22/79)

U. S. GEOLOGICAL SU[illegible]
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 5/80 AT 919 SEQ 1.0001

STATION - 07335500/USGS RED RIVER AT ARTHUR CITY, TX 1891-1976 07335500/USGS



00303

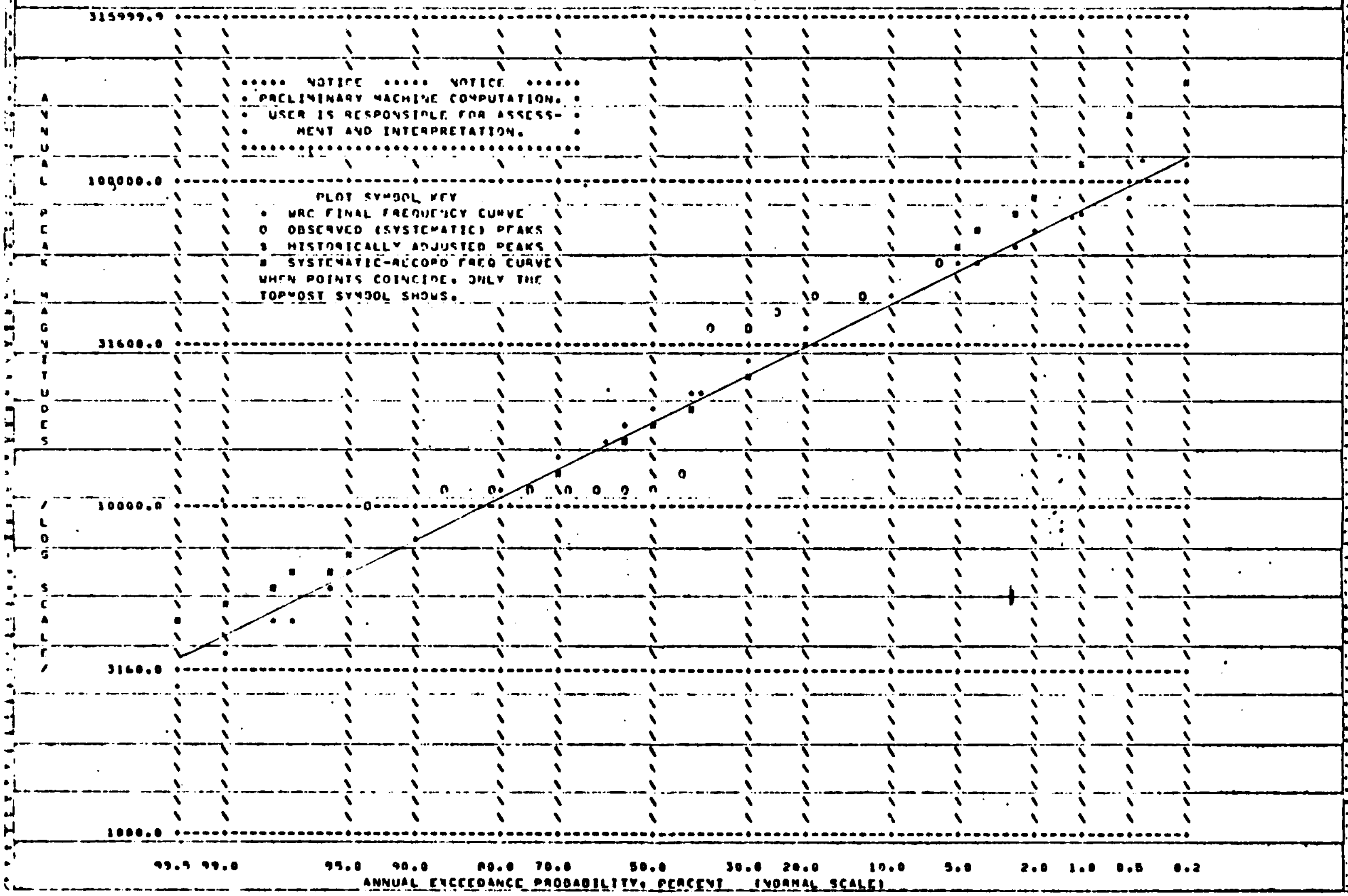
TEXOMA

RGN J407 VER 3.4 (REV 10/22/79)

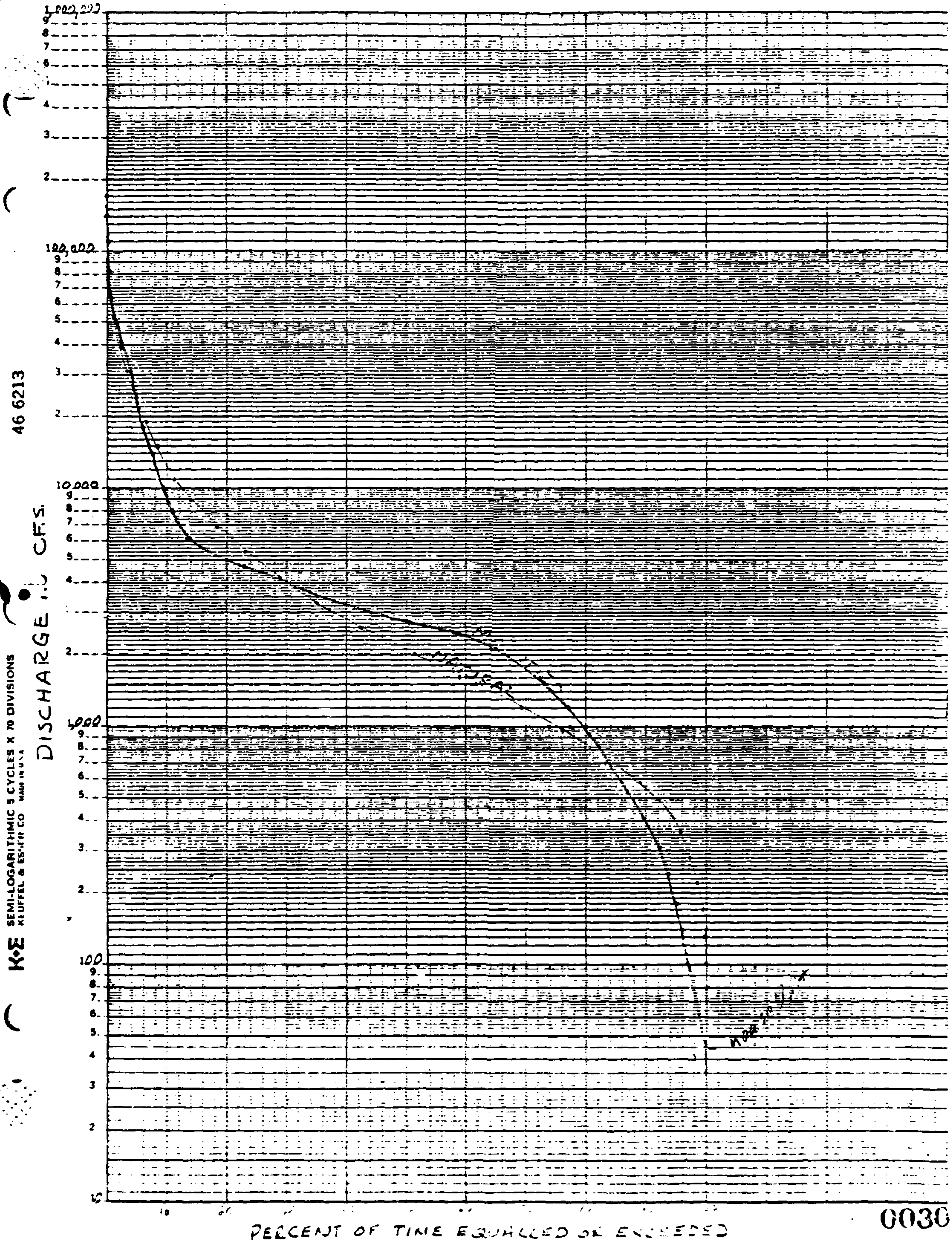
U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 3/80 AT 1600 SEQ 1.0001

STATION - 07331600/USGS RED RIVER AT DENISON DAM NR DENISON, TX 1962-1975 07331600/USGS



TEXOMA- RED RIVER



STORET RETRIEVAL DATE 80/10/09 - STAND - VERSION OF SEP. 1980 STN 1.SUMMARY.1
NO DATA 0.3 MILES BELOW TEXOMA

07331600
33 49 08.0 096 33 47.0 2
RED RIVER AT DENISON DAM NR DENISON, TX
48181 TEXAS GRAYSON
101692

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 59/10/31 TO 80/06/02

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	118	66	29	11	30	29	29	91	22	7
MEAN	16.48	0.095	2.10	236.	3.833	6.79	7.	8.479	0.324	54.3
MEDIAN	17.50	0.060	2.00	200.	1.000	10.00	7.	9.200	0.300	60.0
NO OF VIOLS	0	2	0	0	0	0	0	22	0	0
PERCENT VIOL	0.	3.	0.	0.	0.	0.	0.	24.	0.	0.
MINIMUM VIOL	0.0	0.550	0.0	0.	0.0	0.0	0.	1.700	0.0	0.0
MEAN VIOL	0.0	0.560	0.0	0.	0.0	0.0	0.	3.273	0.0	0.0
MAXIMUM VIOL	0.0	0.570	0.0	0.	0.0	0.0	0.	5.000	0.0	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

00306

STORET RETRIEVAL DATE 80/10/09 - STAND - VERSION OF SEP. 19 STN 1.SUMMARY.2
NO DAT 3 MILES BELOW TEXOMA

07331600
33 49 08.0 096 33 47.0 2
RED RIVER AT DENISON DAM NR DENISON, TX
48181 TEXAS GRAYSON
101692

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 59/10/31 TO 80/06/02

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	092 ZI ZN TOT G/L	00070 TURB JKSN JTU
NO OF VALUES	30	10	28	107	268	268	27	22	28	70
MEAN	33.10	30.00	0.207	0.230	7.619	7.619	0.667	2.73	18.	2.16
MEDIAN	12.00	30.00	0.100	0.110	7.600	7.600	0.0	0.50	10.	2.00
NO OF VIOLS	8	2	0	0	1	0	0	0	0	0
PERCENT VIOL	27.	20.	0.	0.	0.	0.	0.	0.	0.	0.
MINIMUM VIOL	90.00	60.00	0.0	0.0	6.200	0.0	0.0	0.0	0.	0.0
MEAN VIOL	98.75	70.00	0.0	0.0	6.200	0.0	0.0	0.0	0.	0.0
MAXIMUM VIOL	100.00	80.00	0.0	0.0	6.200	0.0	0.0	0.0	0.	0.0
MIN CRITERIA	*********	*********	*********	*********	6.500	*********	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	*********	9.000	10.000	50.00	5000.	50.00

60367

NO DATA 0.3 MILES BELOW TEXOMA

100AN7W278 07331600
33 49 08.0 096 33 47.0 2
RED RIVER AT DENISON DAM
40013 OKLAHOMA
RED RIVER 1016
RED RIVER
21OKOSHO
0000 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 75/11/21 TO 77/09/07

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	23	0	7	0	8	8	8	15	22	0
MEAN	16.09	0.0	2.29	0.	2.000	12.50	4.	7.147	0.324	0.0
MEDIAN	16.00	0.0	2.00	0.	2.000	12.00	4.	6.900	0.300	0.0
NO OF VIOLS	0	0	0	0	0	0	0	6	0	0
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	40.	0.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	1.600	0.0	0.0
MEAN VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	3.150	0.0	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	4.300	0.0	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

STOR[illegible]RIEVAL DATE 80/10/09 - STAND - VERSION OF SEP. 1[illegible] STN 2.SUMMARY.2
WG DATA 0.3 MILES BELOW TEXOMA

100AM7W278 07331600
33 49 08.0 096 33 47.0 2
RED RIVER AT DENISON DAM
40013 OKLAHOMA
RED RIVER 1016
RED RIVER
210KOSMO
0000 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 75/11/21 TO 77/09/07

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	8	0	6	0	19	19	6	8	7	22
MEAN	22.00	0.0	0.533	0.0	7.937	7.937	2.000	3.13	4.	2.56
MEDIAN	14.00	0.0	0.500	0.0	8.000	8.000	1.500	3.00	4.	2.25
NO OF VIOLS	1	0	0	0	1	0	0	0	0	0
PERCENT VIOL	13.	0.	0.	0.	5.	0.	0.	0.	0.	0.
MINIMUM VIOL	90.00	0.0	0.0	0.0	6.200	0.0	0.0	0.0	0.	0.0
MEAN VIOL	90.00	0.0	0.0	0.0	6.200	0.0	0.0	0.0	0.	0.0
MAXIMUM VIOL	90.00	0.0	0.0	0.0	6.200	0.0	0.0	0.0	0.	0.0
MIN CRITERIA	*********	*********	*********	*********	6.500	*********	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	*********	9.000	10.000	50.00	5000.	50.00

1. Project Name: Pat Mayse Lake

2. Project Location: River mile 4.6 on Sanders Creek tributary to Red River. Project watershed (175 square miles) located in Texas; downstream management control stations located in Texas and Arkansas.

3. Type of Project:

a. General Category: multiple-purpose storage reservoir (excluding hydropower).

b. Storage Allocations:

	Elevation (Feet N.G.V.D.)	Storage Acre-Feet	Storage Inches Runoff
Top Flood Control Pool	460.5	189,100	20.26
Top Conservation Pool	451.0	124,500	13.34
Bottom Conservation Pool	415.0	4,600	.49
Water Supply Storage (55 mgd)		109,600	

4. Water Management Criteria:

a. Authorized Project Purpose: flood control, water supply, recreation, and fish and wildlife.

b. Water Use Contracts: Water storage 55 mgd.

c. Interagency Agreements: none

d. Informal Commitments: Agreement with Texas Parks & Wildlife Dept. not to use the low flow pipe in order to prevent the migration of rough fish from downstream into the lake.

e. System Regulation Objections: none.

5. Project Evaluation:

a. Effects of impoundment on Water Stored.

(1) Positive Effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(2) Negative Effects:

(a) Quality: Due to the basin morphometry, Pat Mayse Lake stratifies only occasionally. Such weak and ephemeral stratification is not associated with serious water quality degration.

b. Project Effect on Instream Flows:

(1) General: Natural frequency and duration curves are attached. The downstream reach is short and subject to backwater effects from the Red River.

(2) Negative Effects: Historical data from Pat Mayse tailwater stations were compared to raw water supply standards (see attachments). These drinking water standards were used because Texas has few numerical standards for other water classes. No significant violations of these standards were found.

c. Project Effects on System Regulation: The project has an insignificant effect on the Red River system.

7. Alternatives:

a. Reservoir Regulations: None

b. Structural Modification: None

c. Storage Reallocation: None

d. Other: No action

8. Action Taken to Date: None

9. Planned Action: None

PAT MAYSE
SANDERS CREEK, TEXAS

Top of Conservation (Power) Pool Elevation	451.0
Top of Flood Control Pool Elevation	460.5

OUTLET WORKS

Type	Conduit (Morning Glory Drop Inlet)
Size	7.25' Dia.
Intake Elevation	451.0
Control Gates	None
Capacity at Conservation Pool (c.f.s.)	0
Capacity at Flood Control (c.f.s.)	7800

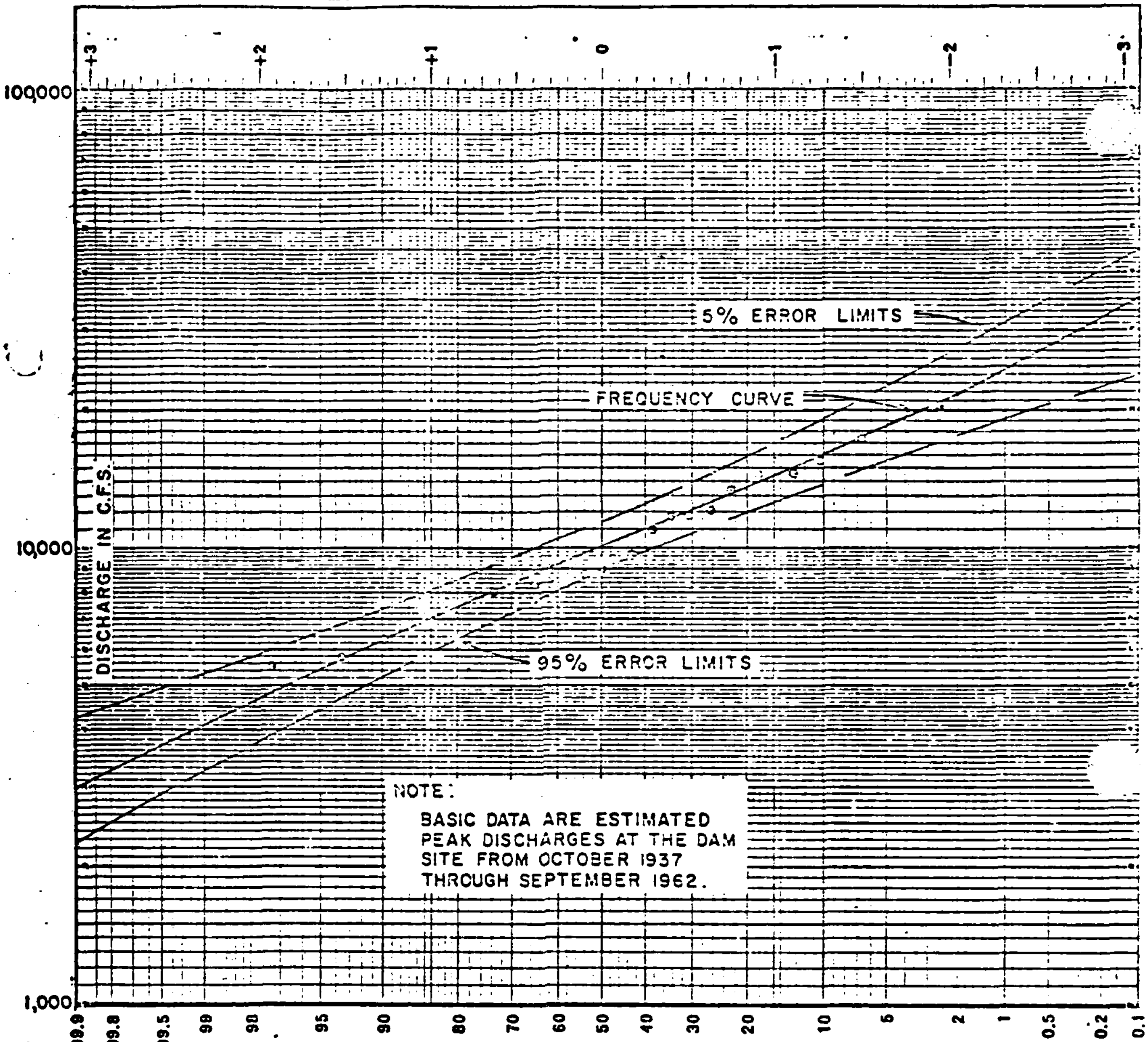
WATER SUPPLY FACILITY

Low Flow	
Type	Pipe
Size	24" Dia.
Elevation	407
Capacity at Conservation Pool (c.f.s.)	125
Capacity at Flood Control Pool (c.f.s.)	138
Static Head Pipe	
Diameter	12" Dia.
Elevation	407.0

SPILLWAY

Type	Excavated
Crest Width	100'
Crest Elevation	477.0
Control	Uncontrolled
Capacity at Conservation Pool (c.f.s.)	0
Capacity at Flood Control Pool (c.f.s.)	0

CORPS OF ENGINEERS U.S. ARMY



PAT MAYSE RESERVOIR

SANDERS CREEK, TEXAS

FREQUENCY CURVE OF ANNUAL FLOOD PEAKS

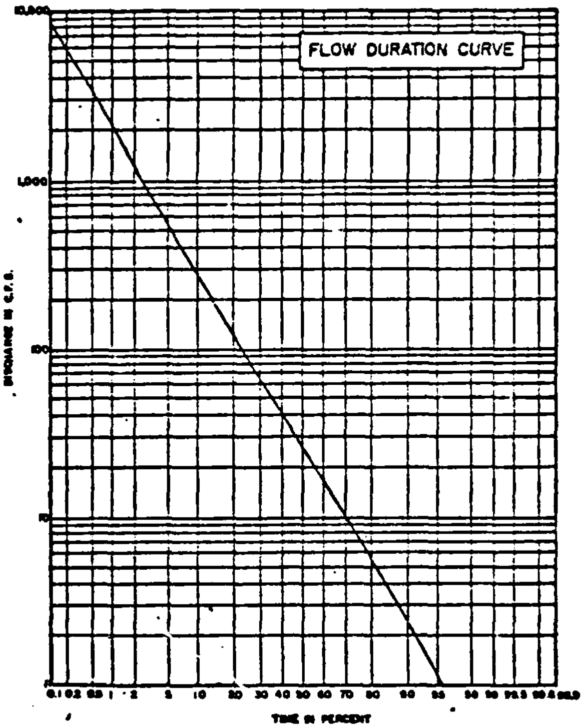
U.S. ARMY ENGINEER DIST., TULSA, CORPS OF ENGINEERS MAR. 64

DRAWN: E.S.S.

CHECKED H.O.R.

00313

PLATE 10



NOTE:

Flow-Duration Curve was computed from natural flows past the dam site for the period of record, 1937-1962.

KEY	DATE	REVISION (INDICATED BY Δ)	CHKD.	REC.	APPR.

U.S. ARMY ENGINEER DISTRICT, TULSA
CORPS OF ENGINEERS
TULSA, OKLAHOMA

RED RIVER WATERSHED — SANDERS CREEK, TEXAS

	BY	CHKD.
DESIGNED:		
DRAWN:	L.D.R.	E.D.S.
TRACED.	T.P.	H.O.R.

SUBMITTED BY: B. D. Baker
CHIEF, GEN. HYDROLOGY

RECOMMENDED: ...
CHIEF, HYDRAULICS BRANCH

PAT MAYSE DAM
EMBANKMENT, OUTLET WORKS & SPILLWAY
HYDROGRAPHS
HYDROGRAPHS III

APPROVED: ...
CHIEF, ENGRS. DIV. FOR THE DISTRICT ENGINEER

DATE: NOV. 1964

SCALE: AS SHOWN

INVITATION NO. CIVENG 34-066-65-61

DRAWING NO. 1102-C1-99/3

STORE RIEVAL DATE 80/10/24 - STAND - VERSION OF SEP. 1 | STN 1.SUMMARY.1
NO DA 1 MILES BELOW PAT MAYSE

07335400
33 51 10.0 095 32 28.0 2
SANDERS CREEK NEAR CHICOTA, TEX.
48277 TEXAS LAMAR
101691

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 61/11/29 TO 67/07/11

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT. UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	7	0	0	0	0	0	0	0	0	0
MEAN	19.36	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MEDIAN	22.22	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
NO OF VIOLS	0	0	0	0	0	0	0	0	0	0
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MEAN VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

00315

STORET RETRIEVAL DATE 80/10/24 - STAND - VERSION OF SEP. 1980
WQ DATA 0.1 MILES BELOW PAT MAYSE

07335400 STN 1.SUMMARY.2
33 51 10.0 095 32 28.0 2
SANDERS CREEK NEAR CHICOTA, TEX.
48277 TEXAS LAMAR
101691

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 61/11/29 TO 67/07/11

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	0	0	0	0	12	12	0	0	0	0
MEAN	0.0	0.0	0.0	0.0	7.133	7.133	0.0	0.0	0.	0.0
MEDIAN	0.0	0.0	0.0	0.0	7.250	7.250	0.0	0.0	0.	0.0
NO OF VIOLS	0	0	0	0	0	2	0	0	0	0
PERCENT VIOL	0.	0.	0.	0.	0.	17.	0.	0.	0.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.0	0.0	6.300	0.0	0.0	0.	0.0
MEAN VIOL	0.0	0.0	0.0	0.0	0.0	6.300	0.0	0.0	0.	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.0	0.0	6.300	0.0	0.0	0.	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	6.500	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	9.000	*********	10.000	50.00	5000.	50.00

00316

1. Project Name: Hugo Lake

2. Project Location: River Mile 17.6 on Kiamichi River tributary to Red River. Project watershed (1,709 square miles) located in Oklahoma; downstream management control stations located in Oklahoma and Arkansas.

3. Type of Project:

a. General Category: Multiple-purpose storage reservoir (excluding hydropower).

b. Storage Allocations:

	Elevation Feet (N.G.V.D.)	Storage Acre-Feet	Storage Inches Runoff
Top Flood Control Pool	437.5	966,700	10.61
Top Conservation Pool	404.5	157,600	1.73
Bottom Conservation Pool	390.0	30,440	.33
Water Supply Storage (58 mgd)		47,600	
Water Quality Storage (90 mgd)		73,900	

4. Water Management Criteria:

a. Authorized Project Purpose: Flood control, water supply, water quality, recreation and fish and wildlife.

b. Water Use Contracts: Water storage - 54.67 mgd

c. Interagency Agreements: None

d. Informal Commitments: None

e. System Regulation Objectives: The project is operated for optimum benefits (flood and conservation) on Kiamichi and lower Red. No quality requirement have been set downstream.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(b) Quantity: The lake provides storage for flow augmentation in times of drought.

(2) Negative effects:

(a) Quality: Hugo Lake becomes thermally stratified from early summer through mid-fall. Chemical reactions within the anoxic hypolimnion cause an increase in dissolved iron and manganese within this zone. The water in the hypolimnion decreases in pH and temperature while ammonia and hydrogen sulfide levels are elevated. When the lake returns to complete mixing in the fall, the water quality becomes more desirable.

(3) Causes of negative effects: Soils within the watershed are high in iron and manganese. Agricultural operations lead to large input of these soils to the lake.

b. Project Effect on Instream Flows:

(1) General: Natural frequency and duration curves are attached. The downstream length is ungaged, short, and subject to backwater effects from the Red River.

(2) Positive effects: Reductions in peak flow magnitudes are expected. The present low flow continuous release of 295 cfs would improve the low flow periods in the stream.

(3) Negative effects: No information is available for Hugo Lake tail-waters. However, these releases are known to be seasonally low in dissolved oxygen and contain high levels of iron and manganese. Violations of State standards for these parameters undoubtedly occur regularly.

(4) Causes of negative effects: Naturally, high quantities or iron and manganese in soils of the watershed enter the lake. Chemical cycling within the hypolimnion elevates levels of these metals in the water which is then released downstream.

c. Project Effects on System Regulation: The project has a significant flood control effect on the Red River.

6. Constraints on Obtaining Instream Quantity and Quality Objectives: Actual low flow requirements have not been set. A water contractor (Western Farmers) will be taking their water from the river about 5 miles downstream of the dam.

7. Alternatives:

a. Reservoir Regulation: None

b. Structural Modification: A selective withdrawal system would improve the quality of downstream releases.

c. Storage Reallocation: None

d. Other: No action.

8. Action Taken To Date: None

9. Planned Action: None

HUGO
KIAMICHI RIVER, OKLAHOMA

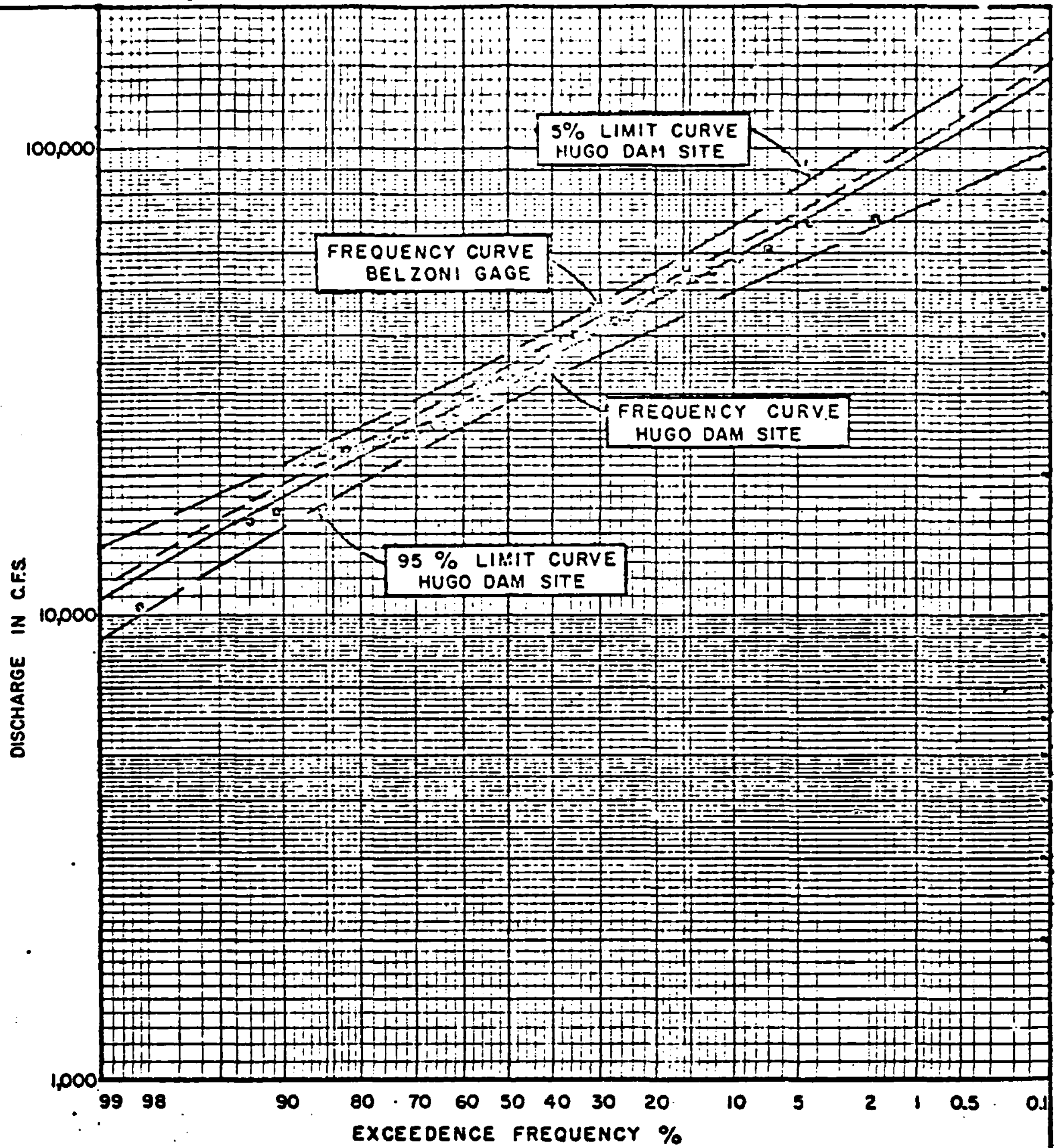
Top of Conservation (Power) Pool Elevation	404.5
Top of Flood Control Pool Elevation	437.5

WATER SUPPLY FACILITY

Low Flow	
Type	Pipe
Size	48" Dia.
Elevation	368.25
Capacity at Conservation Pool (c.f.s.)	415
Static Head Pipe	
Diameter	48" Dia.
Elevation	368.25

SPILLWAY

Type	Ogee
Crest Width	240'
Crest Elevation	387.5
Control	6-40'x50' (Tainter Gates)
Capacity at Conservation Pool (c.f.s.)	55,000
Capacity at Flood Control Pool (c.f.s.)	293,000

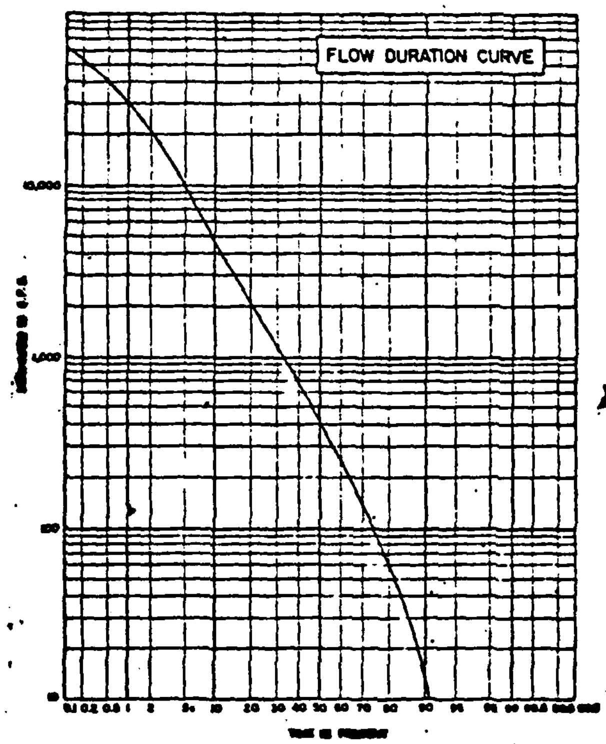


HUGO RESERVOIR
KIAMICHI RIVER, OKLAHOMA

FREQUENCY CURVE OF ANNUAL FLOOD PEAKS

U. S. ARMY ENGINEER DIST., TULSA, CORPS OF ENGINEERS MAY 64
DRAWN: E.B.S
CHECKED: R.Q.R.

00320



U.S. ARMY ENGINEER DISTRICT, TULSA
CORPS OF ENGINEERS
TULSA, OKLAHOMA

DESIGNED BY:	RED RIVER WATERSHED	KIAMICHI RIVER, OKLAHOMA
DRAWN BY:	HUGO DAM SPILLWAY, EMBANKMENT, & ACCESS ROADS HYDROGRAPHS	
CHECKED BY:	HYDROGRAPHS III	
SUBMITTED: [signature] CHIEF, HYDRAULICS BR	INVITATION NO. DACW56-68-B-0076	
	SCALE AS SHOWN	
DATE: MARCH 1968	DRAWING NO. 1400-C2-99/3	

00321

1. Project Name: Pine Creek Lake

2. Project Location: River mile 145.3 on Little River tributary to Red River. Project watershed (635 square miles) located in Oklahoma; downstream management control stations located in Oklahoma and Arkansas.

3. Type of Project:

a. General Category: multiple-purpose storage reservoir (excluding hydropower).

b. Storage Allocations:

	Elevation (Feet N.G.V.D.)	Storage Acre Feet	Storage Inches Runoff
Top Flood Control Pool	480.0	465,780	13.74
Top Conservation Pool	443.5	77,700	2.29
Bottom Conservation Pool	414.0	7,140	.21
Water Supply Storage (84 mgd)		49,400	
Water Quality Storage (36 mgd)		21,100	

4. Water Management Criteria:

a. Authorized Project Purpose: flood control, water supply, water quality, and fish and wildlife.

b. Water Use Contracts: Water storage 49 mgd (30 mgd released downstream for user).

c. Interagency Agreements: Minimum low flow release schedule with EPA.

d. Informal Commitments: None

e. System Regulation Objectives: Regulated in the system to maximize flood control benefits while retaining equivalent flood control capabilities with other projects in the system as much as possible.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive Effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(b) Quantity: The lake provides storage for flow augmentation in times of drought.

(2) Negative Effects:

(a) Quality: Pine Creek Lake becomes thermally stratified from early summer through mid-fall. Chemical reactions within the anoxic hypolimnion cause an increase in dissolved iron and manganese within this zone. The water in the hypolimnion decreases in temperature and pH while ammonia and hydrogen sulfide levels are elevated. When the lake returns to complete mixing in the fall, the water quality becomes more desirable.

(b) Quantity: Flood control operations cause tailwater fluctuations to be greater than normal.

(3) Cause of Negative Effects: Soils within the watershed are high in iron and managanese. Silvicultural operations lead to large input of these soils to the lake.

b. Project Effect on Instream Flows:

(1) General: Discharge frequency and duration curves for natural and modified conditions are attached.

(2) Positive Effects: The peak flow magnitudes have been reduced and the low flow duration have been increased.

(3) Negative Effects: Historical data from Pine Creek tailwater stations were compared to Oklahoma Raw Water Supply Standards (see attachments). These drinking water standards were used because Oklahoma has few numerical standards for other water classes. No significant violations of these parameters were noted; however, the tailwater is known to become low in oxygen and contains high iron and manganese in the stilling basin.

(4) Cause of Negative Effects: Water withdrawn from the hypolimnion for power generation is anoxic. At times, turbulence from the release is insufficient to allow this water to meet State standards immediately below the dam. High levels of dissoved iron and manganese also occur in the hypolimnion as evidenced by levels of these substances in the stilling basin.

c. Project Effects on System Regulation: The project has significant flood control effects on the Little River system.

6. Constraints on Obtaining Instream Quantity and Quality Objectives: Capacity of multilevel intakes is insufficient to regulate for downstream temperature during flood releases.

7. Alternatives:

a. Reservoir Regualtion: None

b. Structural Modification: None

c. Storage Reallocation: None

d. Other: Destratification would increase the water quality of the low flow and flood releases.

8. Action Taken to Date: Tests have been performed to increase the release water quality for low flow rates by pumping surface water downward to the intakes. Improvement was noted.

9. Planned Action: None.

PINE CREEK
LITTLE RIVER, OKLAHOMA

Top of Conservation (Power) Pool Elevation		443.5
Top of Flood Control Pool Elevation		480.0

OUTLET WORKS

Type		Conduit
Size		13' Dia.
Intake Elevation		384.0
Control Gates		2-5.67'x13'
Capacity at Conservation Pool (c.f.s.)		5900
Capacity at Flood Control Pool (c.f.s.)		7650

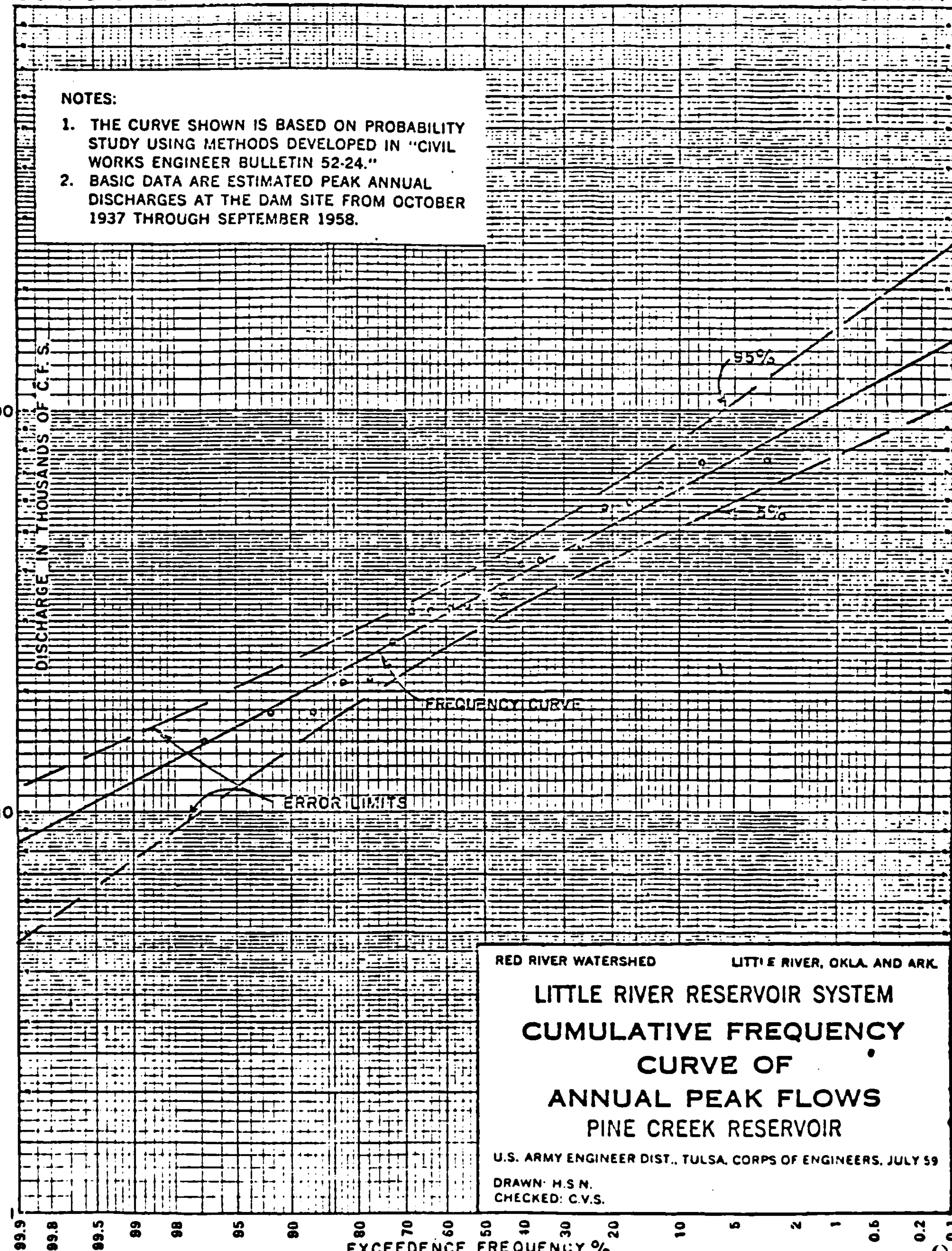
WATER SUPPLY FACILITY

Intakes		
Number	1	1
Size	48" Dia.	48" Dia.
Elevation	423.0	406.0
Low Flow		
Type		Pipe
Size		48" Dia.
Elevation		406.0
Capacity at Conservation Pool (c.f.s.)		370
Static Head Pipe		
Diameter		36" Dia.
Elevation	423.0	407.0

SPILLWAY

Type		Ogee
Crest Width		576'
Crest Elevation		480.0
Control		Uncontrolled
Capacity at Conservation Pool (c.f.s.)		0
Capacity at Flood Control Pool (c.f.s.)		0

CORPS OF ENGINEERS U.S. ARMY



NOTES:

1. THE CURVE SHOWN IS BASED ON PROBABILITY STUDY USING METHODS DEVELOPED IN "CIVIL WORKS ENGINEER BULLETIN 52-24."
2. BASIC DATA ARE ESTIMATED PEAK ANNUAL DISCHARGES AT THE DAM SITE FROM OCTOBER 1937 THROUGH SEPTEMBER 1958.

RED RIVER WATERSHED LITTLE RIVER, OKLA. AND ARK.

LITTLE RIVER RESERVOIR SYSTEM

CUMULATIVE FREQUENCY CURVE OF ANNUAL PEAK FLOWS

PINE CREEK RESERVOIR

U.S. ARMY ENGINEER DIST., TULSA, CORPS OF ENGINEERS, JULY 59

DRAWN: H.S.N.
CHECKED: C.V.S.

00326

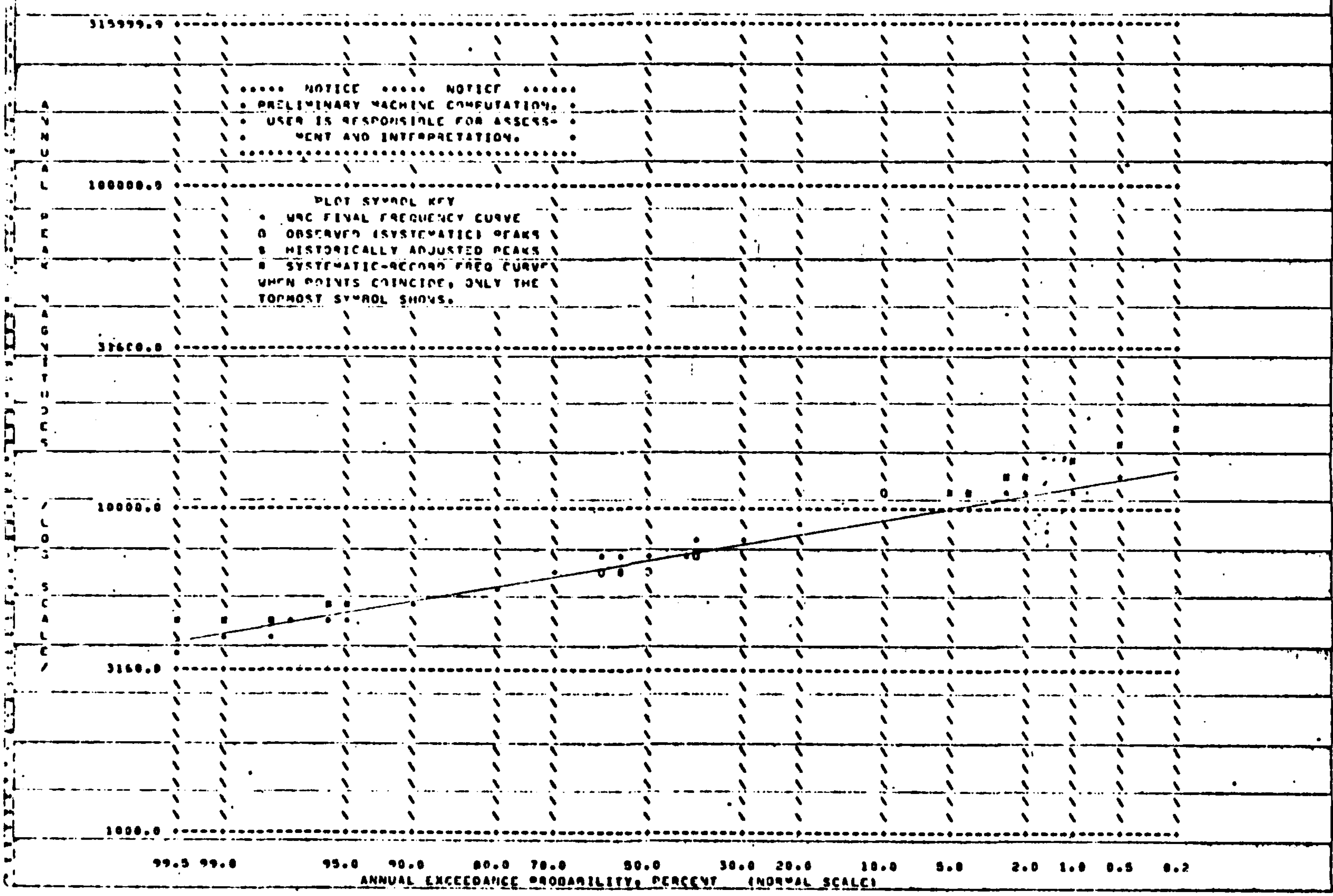
PINE CREEK

PGM J407 VER 3.4
(REV 10/22/79)

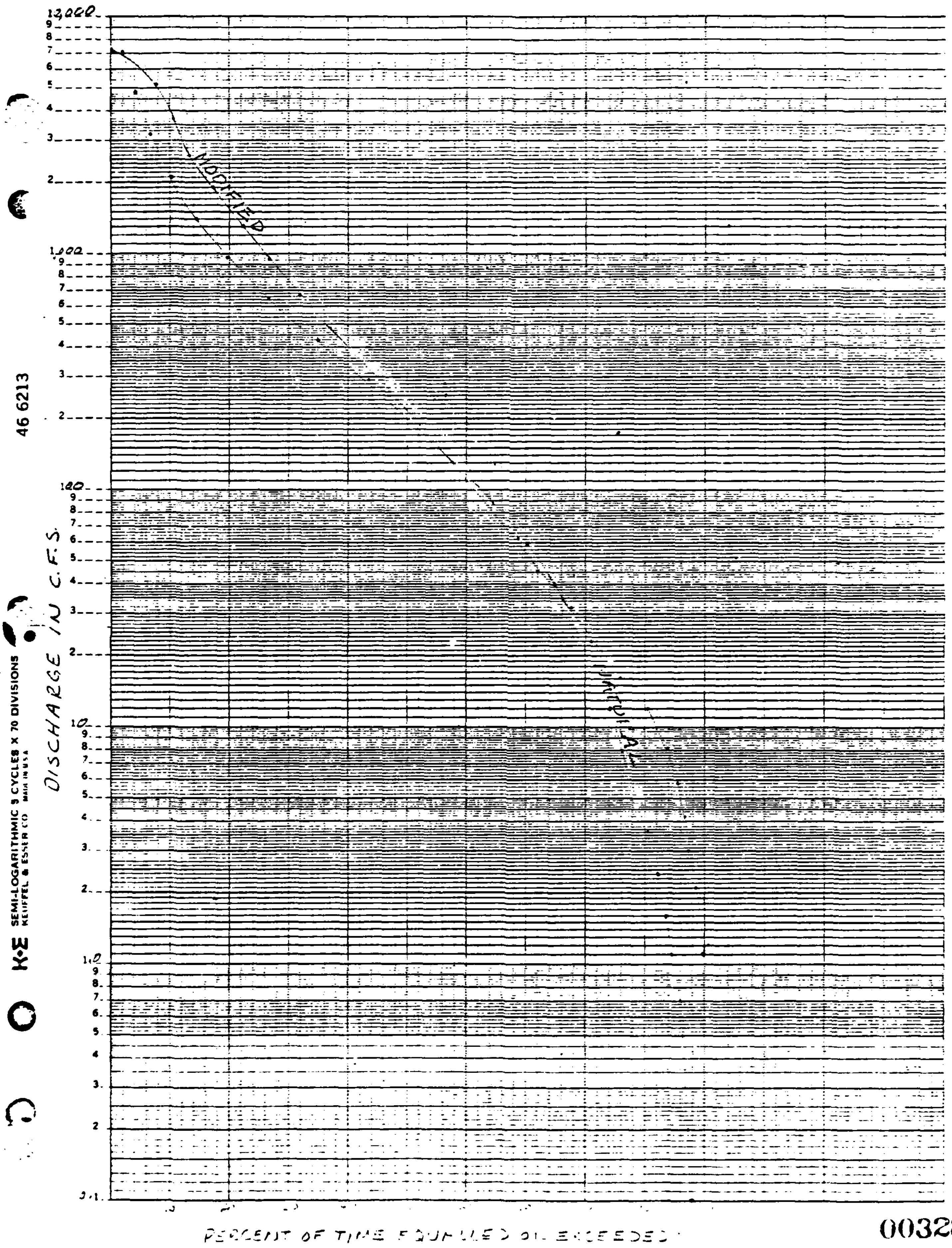
U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 3/80 AT 1557 SEQ 1.0001

STATION - 07337500/USGS LITTLE RIVER NR WRIGHT CITY, OK 1969-1977 07337500/USGS



PINE CREEK — LITTLE R.



00328

STORET RETRIEVAL DATE 80/10/10 - STAND - VERSION OF SEP. 1980
WQ DATA 4.7 MILES BELOW PINE CREEK

07337500
34 04 10.0 095 02 47.0 2
LITTLE RIVER NR WRIGHT CITY, OK
40089 OKLAHOMA MCCURTAIN

/TYPA/AMBNT/STREAM

112WRD 760220
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 69/01/07 TO 76/09/08

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	51	0	4	0	4	4	4	10	11	0
MEAN	13.65	0.0	1.50	0.	1.000	5.50	2.	9.400	0.127	0.0
MEDIAN	12.22	0.0	1.00	0.	1.000	4.50	2.	9.600	0.100	0.0
NO OF VIOLS	0	0	0	0	0	0	0	0	0	0
PERCENT VIOL	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MINIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MEAN VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MAXIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	5.000	*********	*********
MAX CRITERIA	32.20	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

STORET RETRIEVAL DATE 80/10/10 - STAND - VERSION OF SEP. 19 STN 1.SUMMARY.2
WQ DA 47 MILES BELOW PINE CREEK

07337500
34 04 10.0 095 02 47.0 2
LITTLE RIVER NR WRIGHT CITY, OK
40089 OKLAHOMA MCCURTAIN

/TYPA/AMBNT/STREAM

112WRD 760220
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 69/01/07 TO 76/09/08

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	4	0	2	0	11	11	2	4	4	11
MEAN	8.25	0.0	0.500	0.0	7.773	7.773	2.500	1.00	5.	22.85
MEDIAN	6.50	0.0	0.500	0.0	7.900	7.900	2.500	1.00	4.	17.00
NO OF VIOLS	0	0	0	0	0	11	0	0	0	1
PERCENT VIOL	0.	0.	0.	0.	0.	100.	0.	0.	0.	9.
MINIMUM VIOL	0.0	0.0	0.0	0.0	0.0	6.800	0.0	0.0	0.	61.00
MEAN VIOL	0.0	0.0	0.0	0.0	0.0	7.773	0.0	0.0	0.	61.00
MAXIMUM VIOL	0.0	0.0	0.0	0.0	0.0	8.900	0.0	0.0	0.	61.00
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	9.000	6.500	10.000	50.00	5000.	50.00

1. Project Name: Broken Bow Lake

2. Project Location: River mile 20.3 on Mountain Fork River tributary to Little River. Project watershed (754 square miles) located in Oklahoma; downstream management control stations located in Oklahoma and Arkansas.

3. Type of Project:

a. General Category: multiple-purpose storage reservoir (including hydropower).

b. Storage Allocations:

	Elevation (Feet N.G.V.D.)	Storage Acre Feet	Inches Runoff
Top Flood Control Pool	627.5	1,368,800	34.04
Top Conservation Pool	599.5	918,800	22.85
Bottom Conservation Pool	559.0	52,500	11.16

c. Hydropower Category: Peak demand

4. Water Management Criteria:

a. Authorized Project Purpose: flood control, water supply, hydropower, recreation, and fish and wildlife.

b. Water Use Contracts: *none*

c. Interagency Agreements:

1. U.S. Fish and Wildlife agreement to make sufficient releases to maintain 100 cfs below the reregulation dam.
2. SPA (South Western Power Administration)markets power.
3. Oklahoma State Tourism agreement for a 6 cfs release thru spillway for Beaver Bend State Park.

d. Informal Commitments: Agreement with SPA to make power releases to maintain 100 cfs below the reregulation dam.

e. System Regulation Objectives: The project is regulated in the system to maximize power generation and to control floods while retaining equivalent flood control capabilities with other projects in the system.

5. Project Evaluation:

a. Effects of impoundment on Water Stored:

(1) Positive Effects:

Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(2) Negative Effects:

Quality: Broken Bow Lake becomes thermally stratified from early summer through mid-fall. Chemical reactions within the anoxic hypolimnion cause an increase in dissolved iron and manganese within this zone. This water in the hypolimnion decreases in pH and temperature while ammonia and hydrogen sulfide levels are elevated. When the lake returns to complete mixing in the fall, the water quality becomes more desirable.

(3) Cause of Negative Effects: Soils within the watershed are high in iron and manganese. Vilvicultural operations lead to large input of these soils to the lake.

b. Project Effects on Instream Flows:

(1) General: The downstream below the dam has been converted to a cold water put-and-take trout fishery. Discharge frequency and duration curves are attached (both natural and modified conditions).

(2) Positive Effects: Reduction peak flows and increases in low flows have been observed since impoundment.

(3) Negative Effects: Power generation causes tailwater fluctuations to be greater than normal on a daily basis. Historical data from Broken Bow tailwater stations were compared to Oklahoma Raw Water Supply Standards (see attached). These drinking water standards were used because Oklahoma has few numerical standards for other water classes. The only problem area found was water temperature, which exceeded recommended levels for trout in 37 percent of the samples. However, this station is located 10 miles below the dam and the water has warmed significantly during this period. No other significant violations were noted.

c. Project Effects on System Regulation: The project adds a significant flood control capability to the Little Rock system.

6. Constraints on Obtaining Instream Quality and Quantity Objectives: Unable to make selective water level withdrawals for downstream releases. Power releases surge until they are smoothed by the reregulation structure.

7. Alternatives:

a. Reservoir Regulation: Low flow releases made from the diversion tunnel would cool the downstream reach and provide fresh water source for Beaver Bend State Park.

b. Structural Modification: None

c. Storage Reallocation: Reallocation would be necessary to implement 7a.

d. Other: No action.

8. Action Taken to Date: None.

9. Planned Action: None.

BROKEN BOW
MOUNTAIN FORK RIVER, OKLAHOMA

Top of Conservation (Power) Pool Elevation	599.5 (Power)
Top of Flood Control Pool Elevation	627.5

OUTLET WORKS

Type	Penstock (Tunnel)	Diversion (Tunnel)
Size	25.0' Dia.	17.0'
Intakes Elevation	530.0	430.0
Control Gates		4-5.0'x7.0'
Capacity at Conservation Pool (c.f.s.)		
Capacity at Flood Control Pool (c.f.s.)		

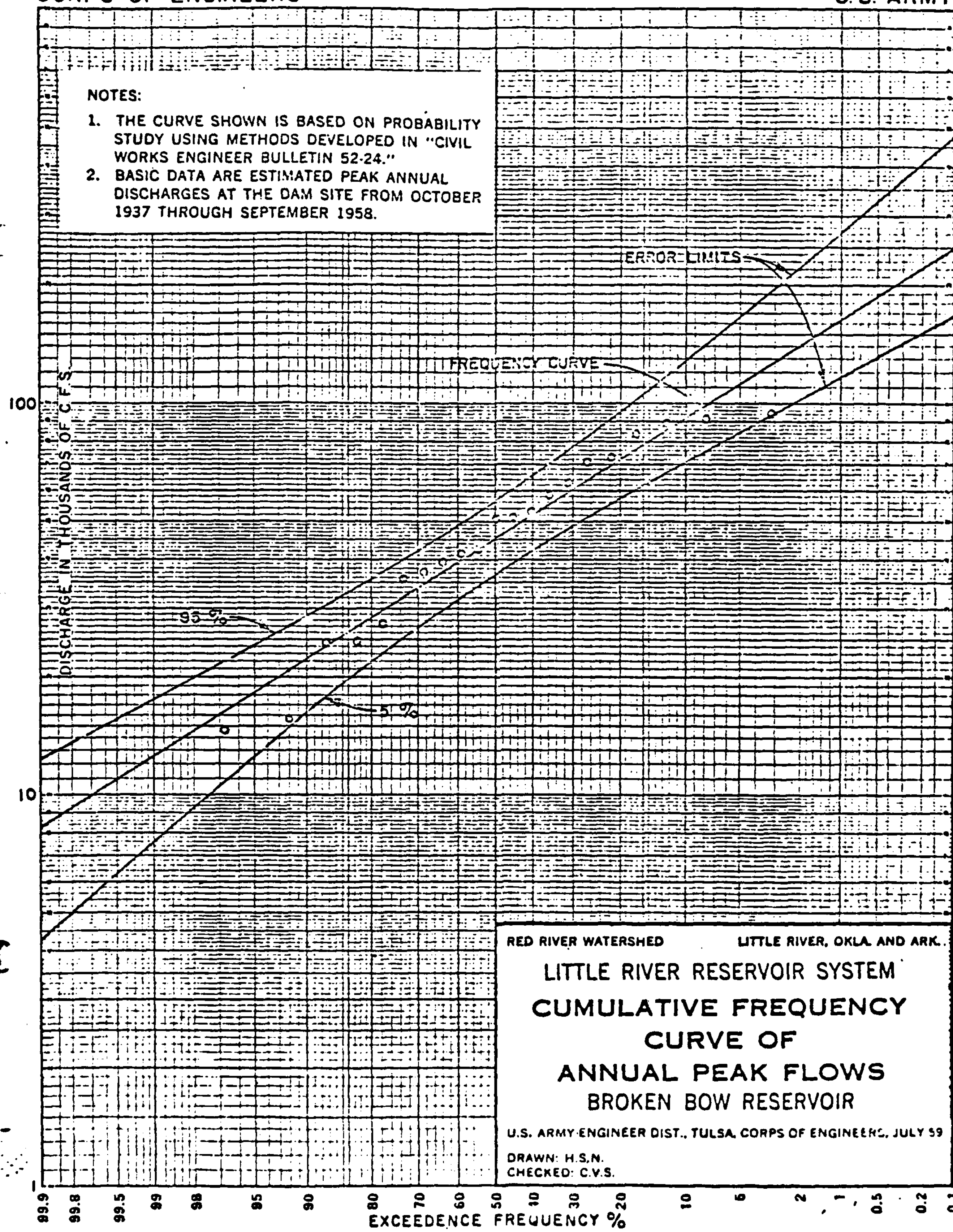
WATER SUPPLY FACILITY

Low Flow	
Type	Sluice
Size	4.0'x4.0'
Elevation	551.0
Capacity at Conservation Pool (c.f.s.)	700
Capacity at Flood Control Pool (c.f.s.)	890
Static Head Pipe	
Diameter	24" Diameter
Elevation	551.0

SPILLWAY

Type	Ogee
Crest Width	320'
Crest Elevation	587.5
Control	8-40'x40' (Tainter Gates)
Capacity at Conservation Pool (c.f.s.)	40,000
Capacity at Flood Control Pool (c.f.s.)	280,000

CORPS OF ENGINEERS U.S. ARMY



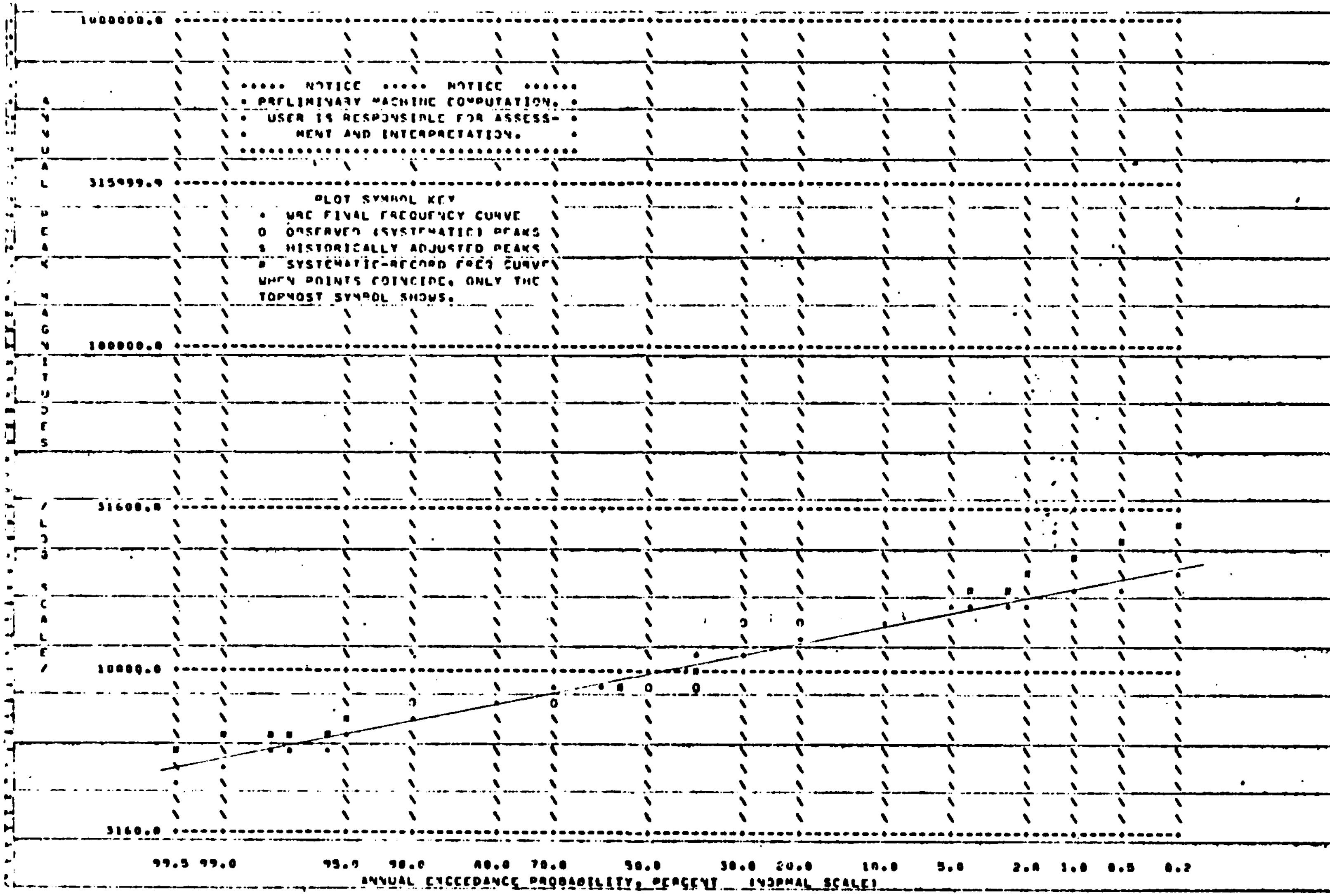
BROKEN BOW

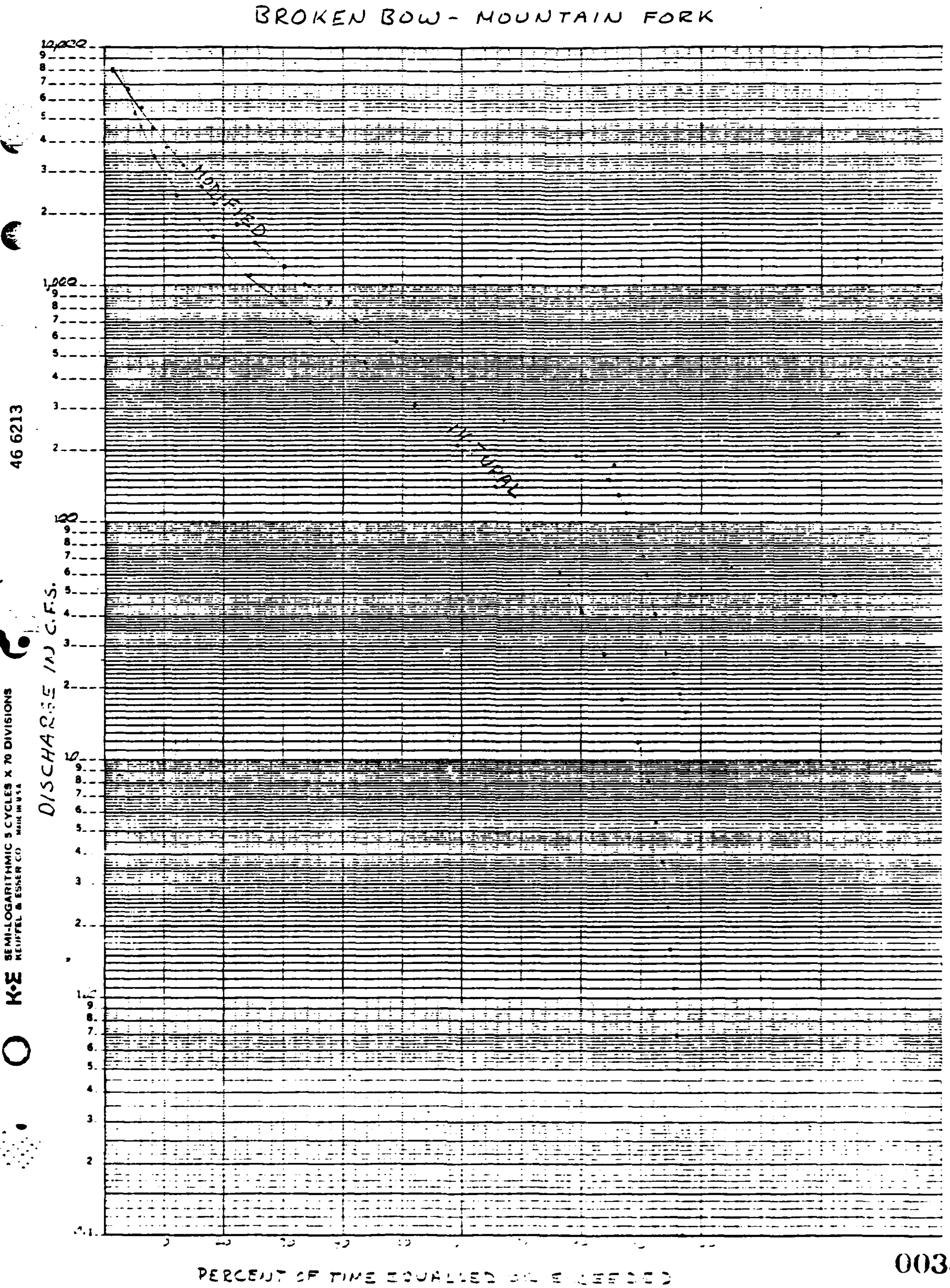
PGM J407 VER 3.4
(REV 10/22/79)

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 3/80 AT 1357 SEQ 1.0001

STATION - 07339000/USGS MOUNTAIN FORK NR EAGLETOWN, OK 1969-1977 07339000/USGS




BROKEN BOW - MOUNTAIN FORK
MODIFIED
NATURAL
DISCHARGE IN C.F.S.
PERCENT OF TIME EQUALLED OR EXCEEDED
K·E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 6213

00337

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STV 1.SUMMARY.1
NO DATA 10 MILES BELOW BROKEN BOW

07339000
34 02 30.0 094 37 15.0 2
MOUNTAIN FORK NR EAGLETOWN, OK
40089 OKLAHOMA MCCURTAIN
101493

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 69/11/18 TO 79/10/11

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	53	0	10	0	12	12	12	45	45	0
MEAN	15.48	0.0	1.40	0.	1.333	12.75	3.	9.811	1.315	0.0
MEDIAN	16.00	0.0	1.00	0.	1.000	13.50	3.	9.400	0.100	0.0
NO OF VIOLS	17	0	0	0	0	0	0	1	9	0
PERCENT VIOL	32.	0.	0.	0.	0.	0.	0.	2.	20.	0.
MINIMUM VIOL	20.50	0.0	0.0	0.	0.0	0.0	0.	3.500	6.000	0.0
MEAN VIOL	23.15	0.0	0.0	0.	0.0	0.0	0.	3.500	6.111	0.0
MAXIMUM VIOL	27.50	0.0	0.0	0.	0.0	0.0	0.	3.500	7.000	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	6.000	*********	*********
MAX CRITERIA	20.00	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

STORET RE... AL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 | STN 1.SUMMARY.2
WG DATA 10 ...ES BELOW BROKEN BOW

0.L39000
34 02 30.0 094 37 15.0 2
MOUNTAIN FORK NR EAGLETOWN, OK
40089 OKLAHOMA MCCURTAIN
101493

/TYPA/AMBNT/STREAM

112WRD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 69/11/18 TO 79/10/11

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	12	0	10	0	46	46	10	12	12	36
MEAN	7.42	0.0	0.560	0.0	7.220	7.220	1.600	1.42	7.	3.504
MEDIAN	7.50	0.0	0.500	0.0	7.200	7.200	1.000	1.00	7.	2.200
NO OF VIOLS	0	0	0	0	6	0	0	0	0	1
PERCENT VIOL	0.	0.	0.	0.	13.	0.	0.	0.	0.	3.
MINIMUM VIOL	0.0	0.0	0.0	0.0	6.100	0.0	0.0	0.0	0.	24.000
MEAN VIOL	0.0	0.0	0.0	0.0	6.300	0.0	0.0	0.0	0.	24.000
MAXIMUM VIOL	0.0	0.0	0.0	0.0	6.500	0.0	0.0	0.0	0.	24.000
MIN CRITERIA	*********	*********	*********	*********	6.500	*********	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	*********	9.000	10.000	50.00	5000.	10.000

00339

STORET RETRIEVAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 2.SUMMARY.1
W3 DATA 10 MILES BELOW BROKEN BOW

1021325 07339000
34 02 30.0 094 37 50.0 2
MOUNTAIN FORK NEAR EAGLETON
40089 OKLAHOMA
RED RIVER 1016
LITTLE RIVER
210KOSHD
0000 FEET DEPTH CLASS 00

/TYPA/AMBNT/STREAM

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 73/04/03 TO 80/07/16

	00010 WATER TEMP CENT	00610 NH3+NH4- N TOTAL MG/L	01002 ARSENIC AS,TOT UG/L	01007 BARIUM BA,TOT UG/L	01027 CADMIUM CD,TOT UG/L	01034 CHROMIUM CR,TOT UG/L	01042 COPPER CU,TOT UG/L	00300 DO MG/L	00951 FLUORIDE F,TOTAL MG/L	01044 IRON FE,SUSP UG/L
NO OF VALUES	52	3	11	0	14	14	13	45	50	0
MEAN	15.80	0.100	2.27	0.	1.357	12.07	4.	9.533	0.121	0.0
MEDIAN	16.25	0.100	1.00	0.	1.000	13.50	3.	9.500	0.100	0.0
NO OF VIOLS	19	0	0	0	0	0	0	2	0	0
PERCENT VIOL	37.	0.	0.	0.	0.	0.	0.	4.	0.	0.
MINIMUM VIOL	21.00	0.0	0.0	0.	0.0	0.0	0.	0.0	0.0	0.0
MEAN VIOL	23.86	0.0	0.0	0.	0.0	0.0	0.	0.750	0.0	0.0
MAXIMUM VIOL	27.50	0.0	0.0	0.	0.0	0.0	0.	1.500	0.0	0.0
MIN CRITERIA	*********	*********	*********	*********	*********	*********	*********	6.000	*********	*********
MAX CRITERIA	20.00	0.500	50.00	1000.	10.000	50.00	1000.	*********	1.400	300.0

00340

STORET RE... VAL DATE 80/10/22 - STAND - VERSION OF SEP. 1980 STN 2.SUMMARY.2
WD DATA 10 MILES BELOW BROKEN BOW

...21325 07339000
34 02 30.0 094 37 50.0 2
MOUNTAIN FORK NEAR EAGLETON
40089 OKLAHOMA
RED RIVER 1016
LITTLE RIVER
/TYPA/AMBNT/STREAM
210KOSHD
0000 FEET DEPTH CLASS 00

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 73/04/05 TO 80/07/16

	01051 LEAD PB,TOT UG/L	01054 MANGNESE MN,SUSP UG/L	71900 MERCURY HG,TOTAL UG/L	00620 NO3-N TOTAL MG/L	00400 PH SU	00400 PH SU	01147 SELENIUM SE,TOT UG/L	01077 SILVER AG,TOT UG/L	01092 ZINC ZN,TOT UG/L	00070 TURB JKSN JTU
NO OF VALUES	14	0	11	2	54	54	11	12	12	57
MEAN	8.00	0.0	0.491	0.150	7.143	7.143	1.818	1.50	7.	4.607
MEDIAN	7.50	0.0	0.500	0.150	7.100	7.100	1.000	1.00	8.	2.500
NO OF VIOLS	0	0	0	0	5	0	0	0	0	4
PERCENT VIOL	0.	0.	0.	0.	9.	0.	0.	0.	0.	7.
MINIMUM VIOL	0.0	0.0	0.0	0.0	5.600	0.0	0.0	0.0	0.	12.000
MEAN VIOL	0.0	0.0	0.0	0.0	6.080	0.0	0.0	0.0	0.	25.000
MAXIMUM VIOL	0.0	0.0	0.0	0.0	6.400	0.0	0.0	0.0	0.	34.000
MIN CRITERIA	*********	*********	*********	*********	6.500	*********	*********	*********	*********	*********
MAX CRITERIA	50.00	50.00	2.000	10.000	*********	9.000	10.000	50.00	5000.	10.000

1. Project Name: DeQueen Lake

2. Project Location: River mile 22.8 on Rolling Fork River tributary to Little River. Project watershed (169 square miles) located in Arkansas; downstream management control stations located in Arkansas.

3. Type of Project:

a. General Category: Multiple-purpose storage reservoir (excluding hydropower).

b. Storage Allocations:

	Elevation Feet (N.G.V.D.)	Storage Acre-Feet	Storage Inches Runoff
Top Flood Control Pool	473.5	136,200	15.11
Top Conservation Pool	437.0	34,900	3.87
Bottom Conservation Pool	415.0	9,350	1.04
Water Supply Storage (22 mgd)		17,900	
Water Quality Storage (10 mgd)		7,600	

4. Water Management Criteria:

a. Authorized Project Purpose: Flood control, water supply, water quality, recreation, and fish and wildlife.

b. Water Use Contracts: Pending water storage - (1) - 22 mgd.

c. Interagency Agreements: Minimum low flow release schedule with EPA.

d. Informal Commitments:

(1) To regulate for a maximum change in downstream water temperature of 1° C/HR.

(2) To regulate for an objective stream water temperature curve.

e. System Regulation Objectives: The project is regulated in the system to control floods while retaining equivalent flood control capabilities with other projects in the system.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(b) Quantity: The lake provides storage for flow augmentation in times of drought.

(2) Negative effects:

(a) Quality: DeQueen Lake becomes thermally stratified from early summer through mid-fall. Chemical reactions within the anoxic hypolimnion cause an increase in dissolved iron and manganese within this zone. The water in the hypolimnion decreases in pH and temperature while ammonia and hydrogen sulfide levels are elevated. When the lake returns to complete mixing in the fall, the water quality becomes more desirable.

(3) Cause of negative effects: Soils within the watershed are high in iron and manganese.

b. Project Effect on Instream Flows:

(1) General: Natural frequency and duration curves are attached. The predicted duration curve for modified conditions is included.

(2) Positive effects: Peak flow magnitudes are expected to be reduced and low flow durations have been increased.

(3) Negative effects: The water quality is basically good, however, hypolimnetic discharges required for flood control are low in dissolved oxygen and high in iron, manganese, and sulfides.

c. Project Effects on System Regulation: The project has significant flood control effects on the Little River system.

6. Constraints on Obtaining Instream Quantity and Quality Objectives:

a. Capacity of multilevel intakes is insufficient to satisfy temperature objectives during flood releases.

b. Transition from flood to low flow releases, and vice versa, requires up to 12 gate changes at one hour intervals to maintain the $1^{\circ}C/hr$ agreement.

7. Alternatives:

a. Reservoir Regulation: None.

b. Structural Modification: A modification allowing for surface withdrawals during flood operations would improve the quality of the releases.

c. Storage Reallocation: None.

d. Other: Destratification would improve the quality of flood releases.

e. No action.

8. Action Taken to Date: None.

9. Planned Action: None.

DEQUEEN
ROLLING FORK RIVER, ARKANSAS

Top of Conservation (Power) Pool Elevation	437.0
Top of Flood Control Pool Elevation	473.5

OUTLET WORKS

Type	Conduit
Size	12.0' Dia.
Intake Elevation	367.0
Control Gates	2-5.67'x12'
Capacity at Conservation Pool (c.f.s.)	5150
Capacity at Flood Control Pool (c.f.s.)	6400

WATER SUPPLY FACILITY

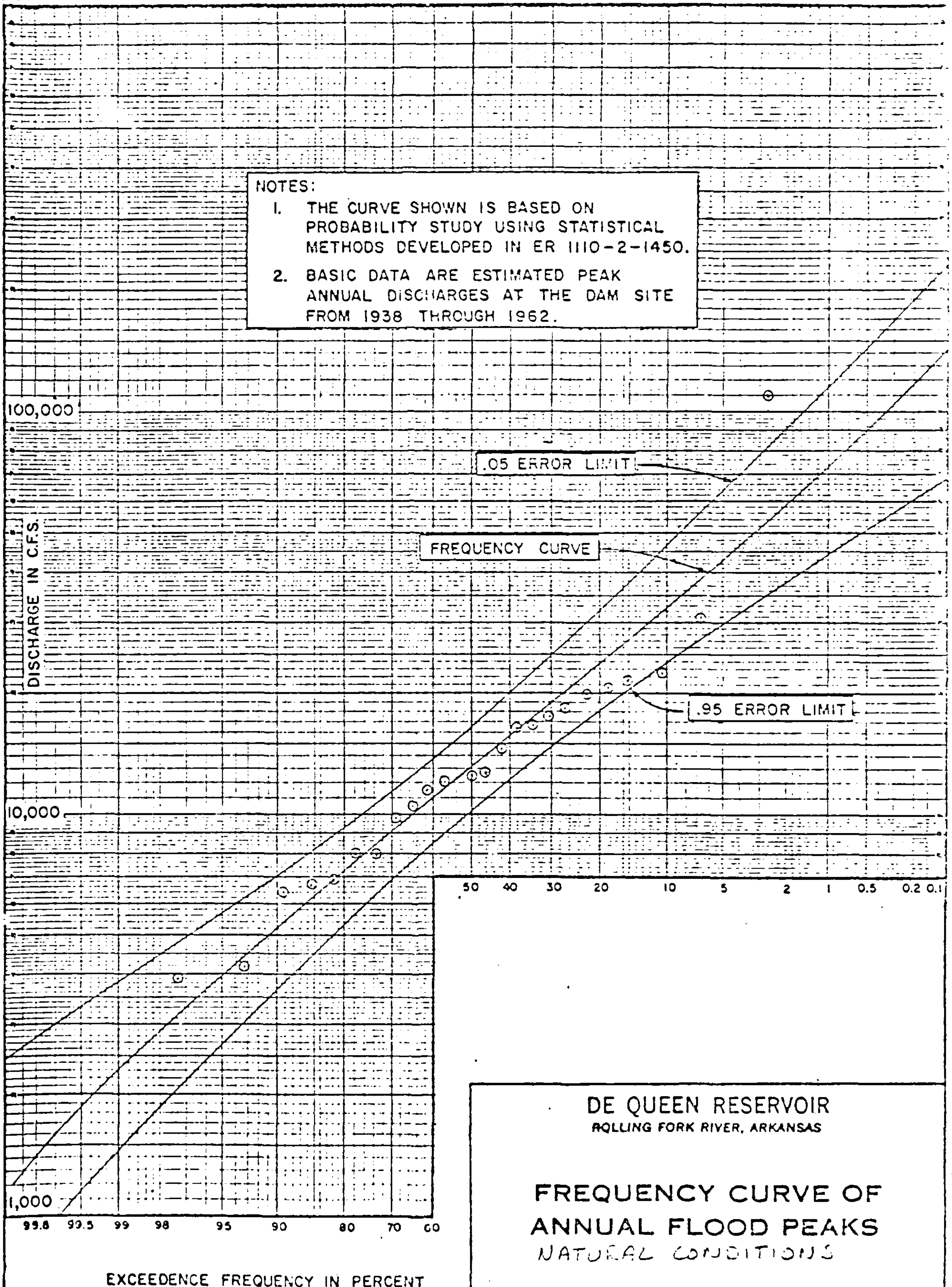
Intakes			
Number	1	1	1
Size	3'x3'	3'x3'	3.0' Dia.
Elevation	431.5	426.0	400.5

Low Flow			
Type		Pipe	
Size		36" Dia.	
Elevation			
Capacity at Conservation Pool (c.f.s.)	115	177	194
Capacity at Flood Control Pool (c.f.s.)	250	250	250

Static Head Pipe		
Diameter	42" Dia.	
Elevation	420.25	400.25

SPILLWAY

Type	Excavated
Crest Width	200'
Crest Elevation	504.0
Control	Uncontrolled
Capacity at Conservation Pool (c.f.s.)	0
Capacity at Flood Control Pool (c.f.s.)	0



DE QUEEN RESERVOIR

ROLLING FORK RIVER, ARKANSAS

FREQUENCY CURVE OF ANNUAL FLOOD PEAKS

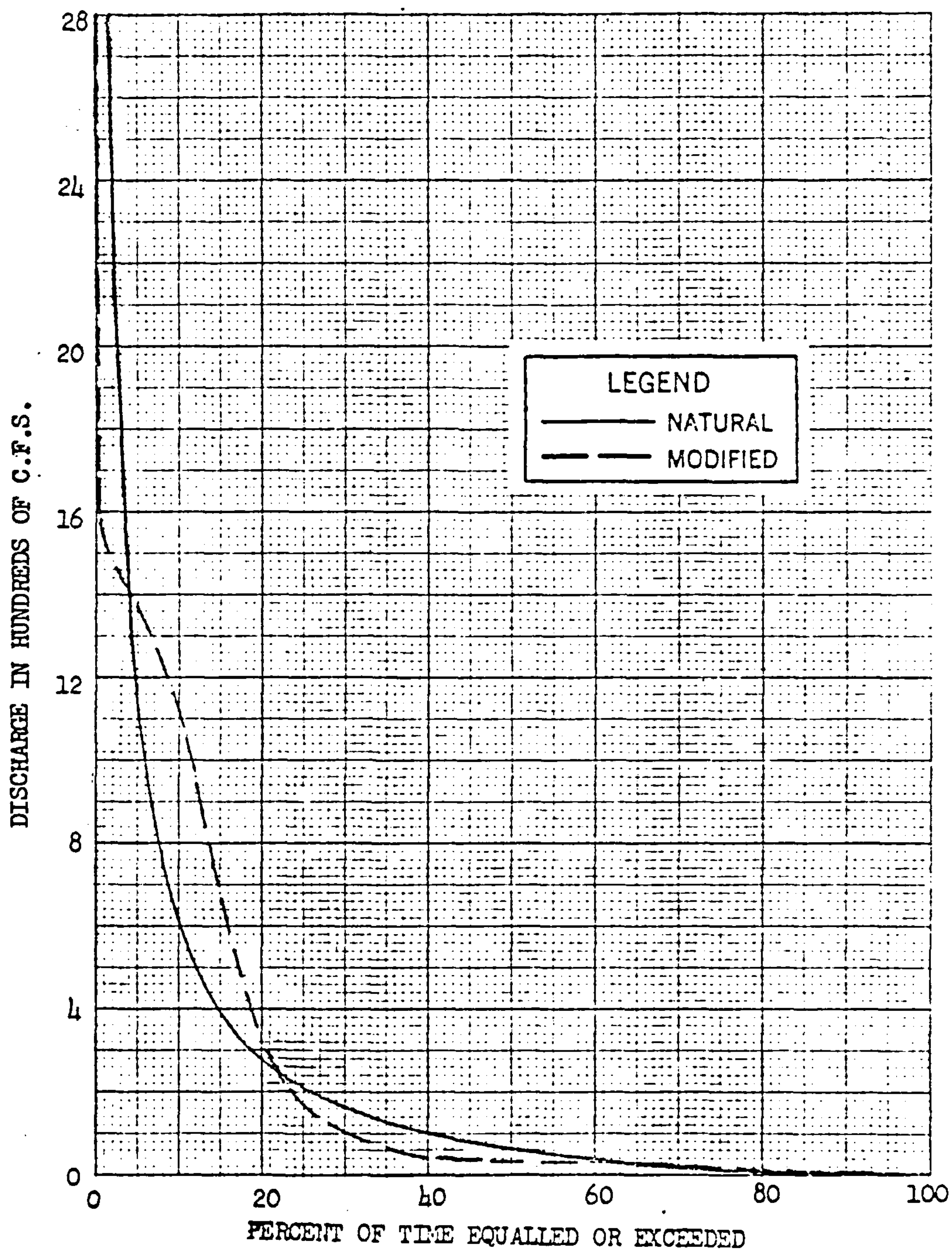
NATURAL CONDITIONS

U. S. ARMY ENGINEER DIST., TULSA, CORPS OF ENGINEERS SEPT. 63

DRAWN: E.B.S.

CHECKED: H.O.R.

C8346



DEQUEEN LAKE

ROLLING FORK RIVER, ARKANSAS

FLOW DURATION CURVE

FOR ULTIMATE PROJECT

AT DEQUEEN DAM SITE

00347

U.S. ARMY ENGINEER DIST., TULSA, CORPS OF ENGINEERS NOV. 71

DRAWN: S. H.

CHECKED: J. L. M.

PLATE 6

1. Project Name: Gillham Lake

2. Project Location: River mile 49.0 on Cossatot River tributary to Little River. Project watershed (271 square miles) located in Arkansas; downstream management control stations located in Arkansas.

3. Type of Project:

a. General Category: Multiple-purpose storage reservoir (excluding hydropower).

b. Storage Allocations:

	Elevation Feet (N.G.V.D.)	Storage Acre-Feet	Storage Inches Runoff
Top Flood Control Pool	569.0	221,800	15.34
Top Conservation Pool	502.0	33,100	2.29
Bottom Conservation Pool	464.5	3,700	.26
Water Supply Storage (42 mgd)		20,600	
Water Quality Storage (18 mgd)		8,800	

4. Water Management Criteria:

a. Authorized Project Purpose: Flood control, water supply, water quality, and fish and wildlife.

b. Water Use Contracts: Pending water storage - (1) - 42 mgd.

c. Interagency Agreements:

(1) Minimum low flow release schedule with EPA.

(2) Special releases for EWQOS program during 6-year study period with WES.

d. Informal Commitments:

(1) To regulate for a maximum change in downstream water temperature of 1° C/HR.

(2) To regulate for an objective stream water temperature curve.

e. System Regulation Objectives: The project is regulated in the system to control floods while retaining equivalent flood control capabilities with other projects in the system.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

(b) Quantity: The lake provides storage for flow augmentation in times of drought.

(2) Negative effects:

(a) Quality: Gillham Lake becomes thermally stratified from early summer through mid-fall. Chemical reactions within the anoxic hypolimnion cause an increase in dissolved iron and manganese within this zone. The water in the hypolimnion decreases in pH and temperature while ammonia and hydrogen sulfide levels are elevated. When the lake returns to complete mixing in the fall, the water quality becomes more desirable.

(3) Cause of negative effects: Soils within the watershed are high in iron and manganese.

b. Project Effect on Instream Flows:

(1) General: Natural frequency and duration curves are attached. The predicted duration curve for modified conditions is inclosed.

(2) Positive effects: Peak flow magnitudes are expected to be reduced and low flow durations have been increased.

(3) Negative effects: The water quality is basically good, however, hypolimnetic discharges required for flood control are low in dissolved oxygen and high in iron, manganese, and sulfides.

c. Project Effects on System Regulation: The project has significant flood control effects on the Little River system.

6. Constraints on Obtaining Instream Quantity and Quality Objectives: Capacity of multilevel intakes is insufficient to satisfy downstream temperature objectives during flood releases. Transition from flood to low flow releases, and vice versa, requires up to 12 gate changes at one hour intervals to maintain the $1^{\circ}C/hr$ agreement.

7. Alternatives:

a. Reservoir Regulation: None.

b. Structural Modification: A modification allowing for surface withdrawals during flood operations would improve the quality of the releases.

c. Storage Reallocation: None.

d. Other: Destratification would improve the quality of flood releases.

e. No action.

8. Action Taken to Date: None.

9. Planned Action: None.

GILLHAM
COSSATOT RIVER, ARKANSAS

Top of Conservation (Power) Pool Elevation		502
Top of Flood Control Pool Elevation		569

OUTLET WORKS

Type		Tunnel
Size		10.0' Dia.
Intake Elevation		437
Control Gates		2-4.5'x10'
Capacity at Conservation Pool (c.f.s.)		3450
Capacity at Flood Control Pool (c.f.s.)		4030

WATER SUPPLY FACILITY

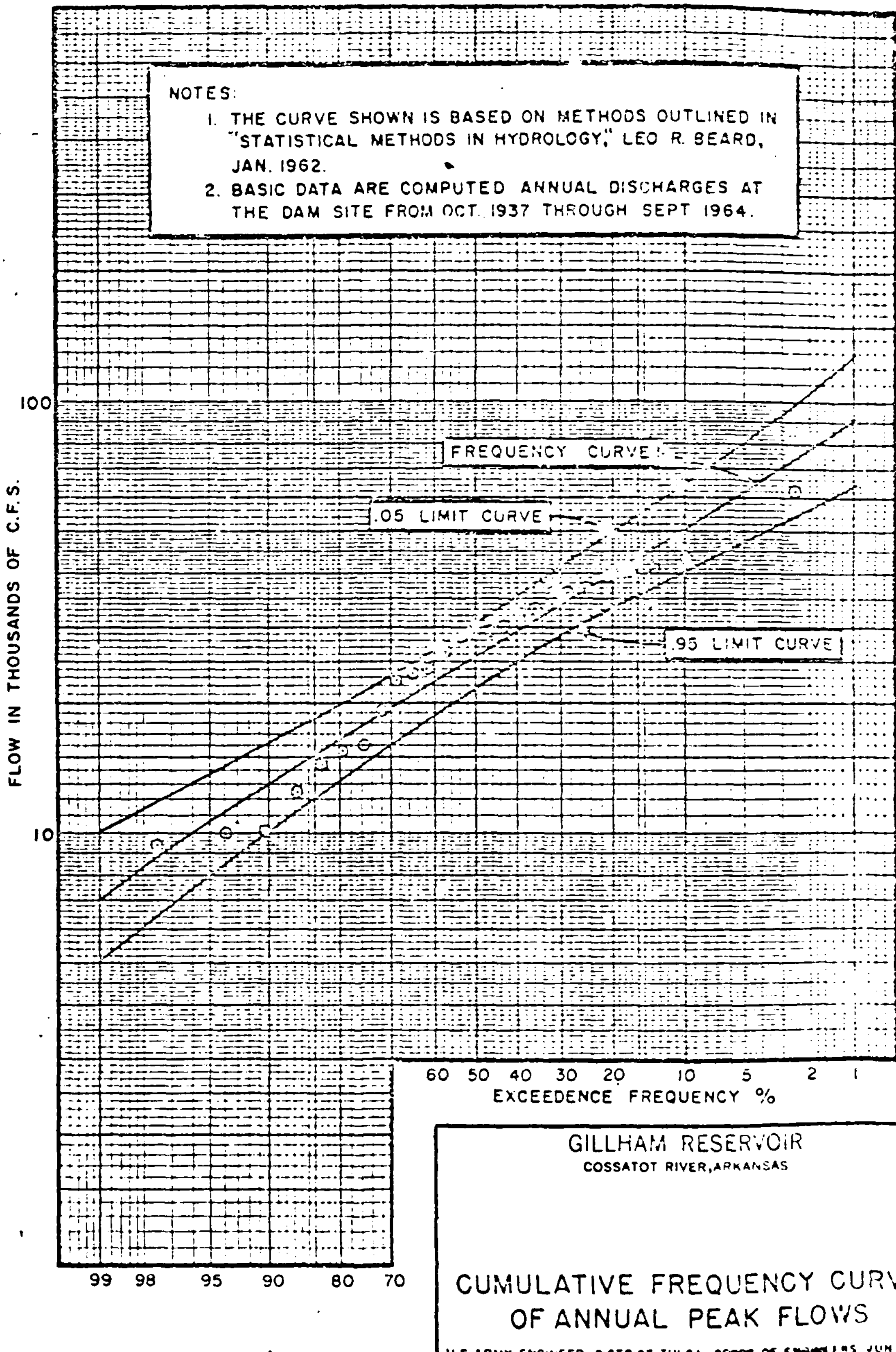
Intakes		
Number	1	1
Size	2.5'x4'	2.5'x4'
Elevation	487	472
Low Flow		
Type		Pipe
Size		30" Dia.
Elevation		472
Capacity at Conservation Pool (c.f.s.)		151
Static Head Pipe		
Diameter		24" Dia.
Elevation		477 and 458.5

SPILLWAY

Type		Ogee
Crest Width		200
Crest Elevation		527
Control	4-50'x42'	(Tainter Gates)
Capacity at Conservation Pool (c.f.s.)		0
Capacity at Flood Control Pool (c.f.s.)		185,000

CORPS OF ENGINEERS U. S ARMY

NATURAL



GILLHAM RESERVOIR

COSSATOT RIVER, ARKANSAS

CUMULATIVE FREQUENCY CURVE OF ANNUAL PEAK FLOWS

U.S. ARMY ENGINEER DISTRICT, TULSA, CORPS OF ENGINEERS JUN 1966

DRAWN: J.A.K.

CHECKED: H.O.R.

1770 - DM 2 - 99/5

00352

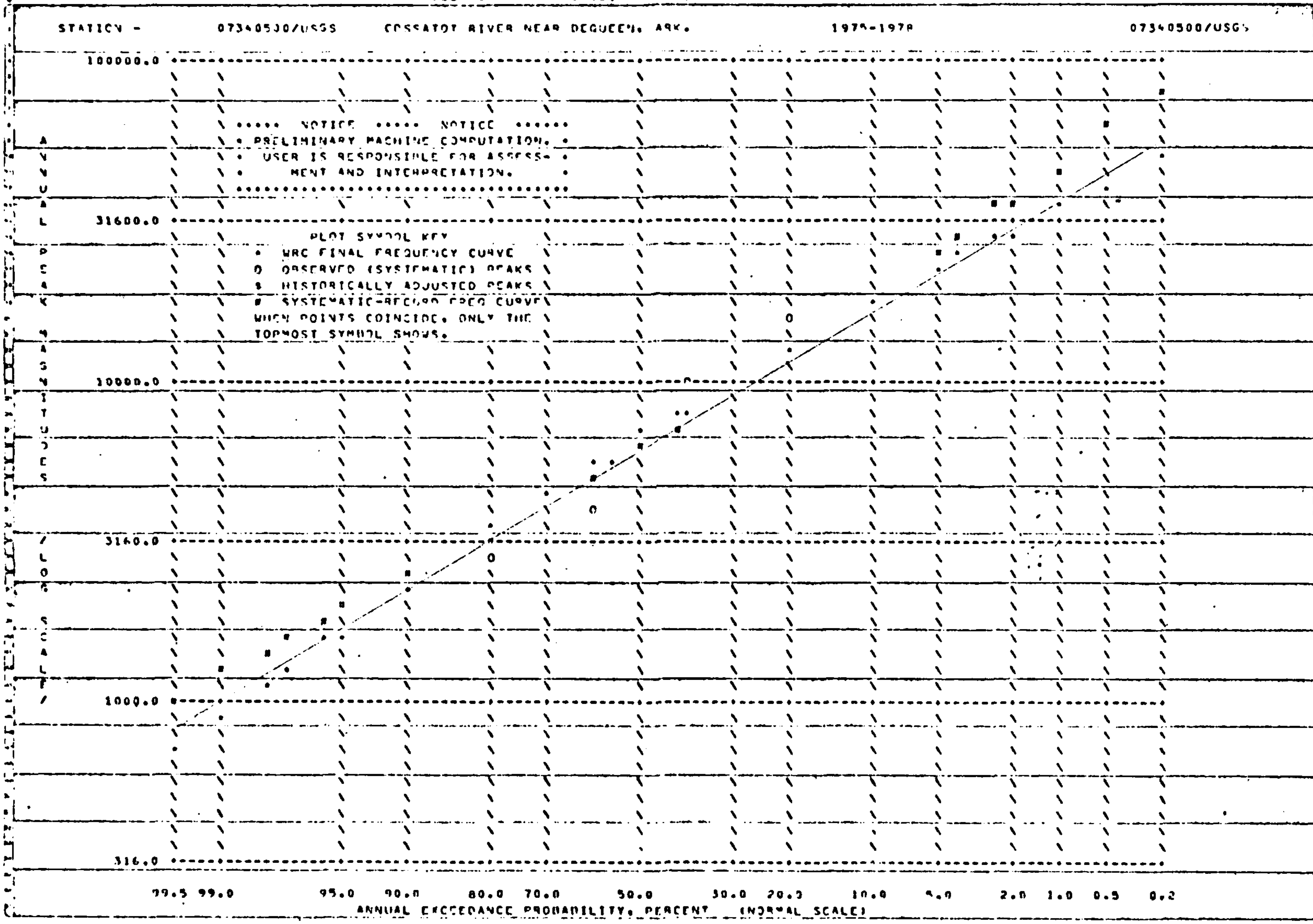
MODIFIED GILLHAM

PSM J407 VER 3.4
(REV 10/22/79)

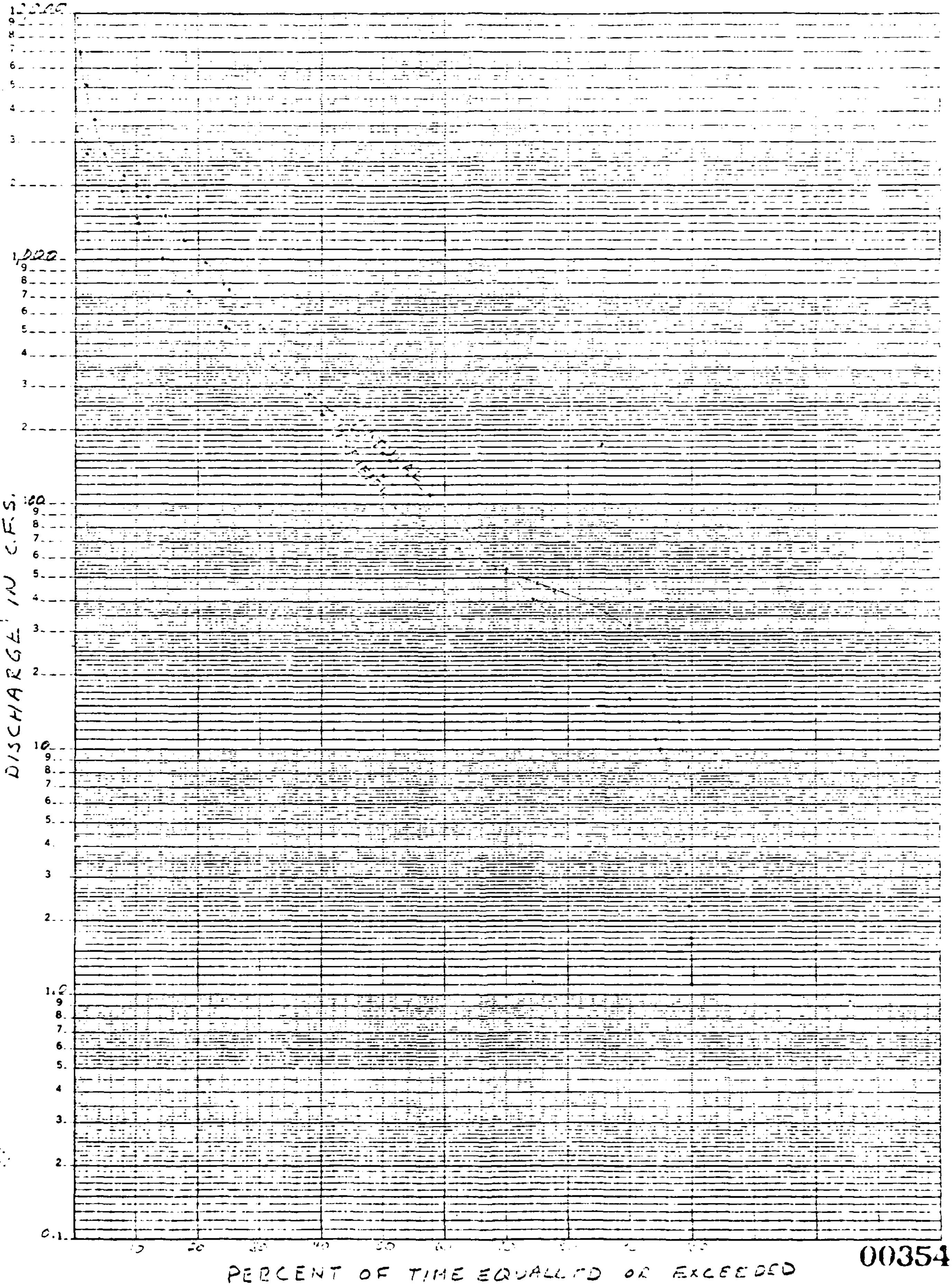
U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 3/80 AT 1515 SEQ 1.0001

STATION - 07340530/USGS COSSATOT RIVER NEAR DEQUEEN, ARK. 1975-1978 07340500/USGS



GILLHAM- COSSATOT R.



00354

1. Project Name: Dierks Lake

2. Project Location: River mile 56.6 on Saline River tributary to Little River. Project watershed (114 square miles) located in Arkansas; downstream management control stations located in Arkansas.

3. Type of Project:

a. General Category: Multiple-purpose storage reservoir (excluding hydropower).

b. Storage Allocations:

	Elevation Feet (N.G.V.D.)	Storage Acre-Feet	Storage Inches Runoff
Top Flood Control Pool	557.5	96,800	15.92
Top Conservation Pool	526.0	29,700	4.88
Bottom Conservation Pool	512.0	14,600	2.40
Water Supply Storage (13 mgd)		10,600	
Low Flow Augmentation (6 mgd)		4,300	

c. Hydropower Category: None.

4. Water Management Criteria:

a. Authorized Project Purpose: Flood control, water supply, low flow augmentation, recreation, and fish and wildlife.

b. Water Use Contracts: Water storage - 13 mgd.

c. Interagency Agreements: Minimum low flow release schedule with EPA.

d. Informal Commitments:

(1) To regulate for a maximum change in downstream water temperature of 1° C/HR.

(2) To regulate for an objective stream water temperature curve.

e. System Regulation Objectives: The project is regulated in the system to control floods while retaining equivalent flood control capabilities with other projects in the system.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stresm.

(b) Quantity: The lake provides storage for flow augmentation in times of drought.

(2) *Negative effects:*

(a) Quality: Dierks Lake becomes thermally stratified from early summer through mid-fall. Chemical reactions within the anoxic hypolimnion cause an increase in dissolved iron and manganese within this zone. The water in the hypolimnion decreases in pH and temperature while ammonia and hydrogen sulfide levels are elevated. When the lake returns to complete mixing in the fall, the water quality becomes more desirable.

(3) Cause of negative effects: Soils within the watershed are high in iron and manganese.

b. Project Effect on Instream Flows:

(1) General: Discharge frequency and duration curves for natural and modified conditions are attached.

(2) Positive effects: Peak flow magnitudes have been reduced and low flow durations have been increased.

(3) Negative effects: The water quality is basically good, however, hypolimnetic discharges required for flood operations are low in dissolved oxygen and high in iron, manganese, and sulfides.

c. Project Effects on System Regulation: The project has significant flood control effects on the Little River system.

6. Constraints on Obtaining Instream Quantity and Quality Objectives:

a. Capacity of multilevel intakes is insufficient to satisfy temperature objectives during flood releases.

b. Transition from flood to low flow releases, and vice versa, requires up to 12 gate changes at one hour intervals to maintain the $1^{\circ}C/hr$ agreement.

7. Alternatives:

a. Reservoir Regulation: None

b. Structural Modification: A modification allowing for surface withdrawals during flood operations would improve the quality of the releases.

c. Storage Reallocation: None.

d. Other: Destratification would improve the quality of flood releases.

e. No action.

8. Action Taken to Date: None.

9. Planned Action: None.

DIERKS
SALINE RIVER, ARKANSAS

Top of Conservation (Power) Pool Elevation		526.0
Top of Flood Control Pool Elevation		557.5

OUTLET WORKS

Type		Conduit
Size		6'x9'
Intake Elevation		448.0
Control Gates		2-3.25x8'
Capacity at Conservation Pool (c.f.s.)		1980
Capacity at Flood Control Pool (c.f.s.)		2370

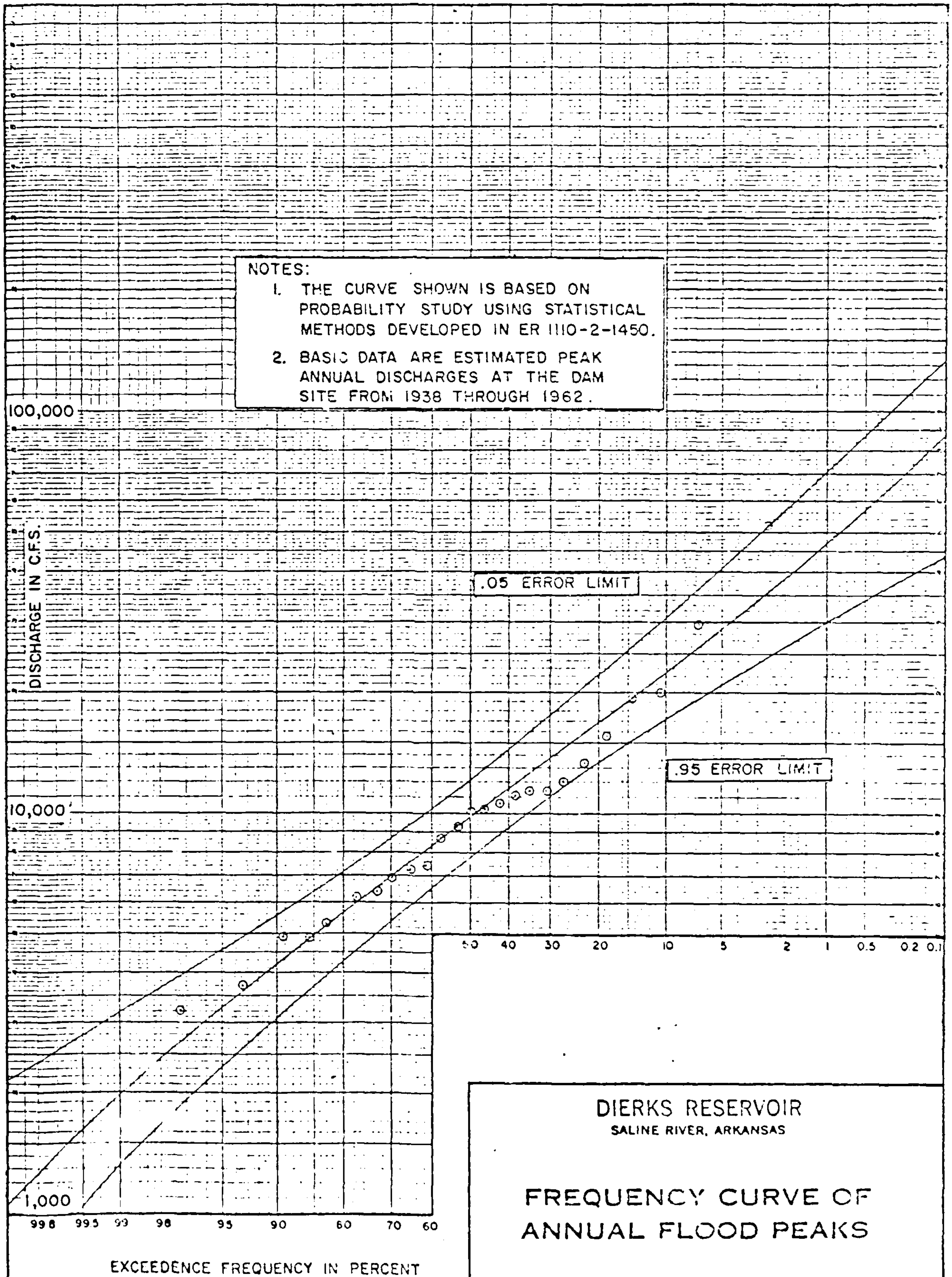
WATER SUPPLY FACILITY

Intakes		
Number	1	1
Size	3'x3'	3'x3'
Elevation	515.0	508.0
Low Flow		
Type		Sluice
Size		1.25'x2.5'
Elevation		460.5
Capacity at Conservation Pool (c.f.s.)		131
Static Head Pipe		
Diameter		30" Dia.
Elevation		465.0

SPILLWAY

Type		Excavated
Crest Width		780'
Crest Elevation		575.0
Control		Uncontrolled
Capacity at Conservation Pool (c.f.s.)		0
Capacity at Flood Control Pool (c.f.s.)		0

NATURAL



DIERKS RESERVOIR
SALINE RIVER, ARKANSAS

FREQUENCY CURVE OF ANNUAL FLOOD PEAKS

U. S. ARMY ENGINEER DIST., TULSA, CORPS OF ENGINEERS SEPT 63
DRAWN: E.B.S.
CHECKED: H.O.R.

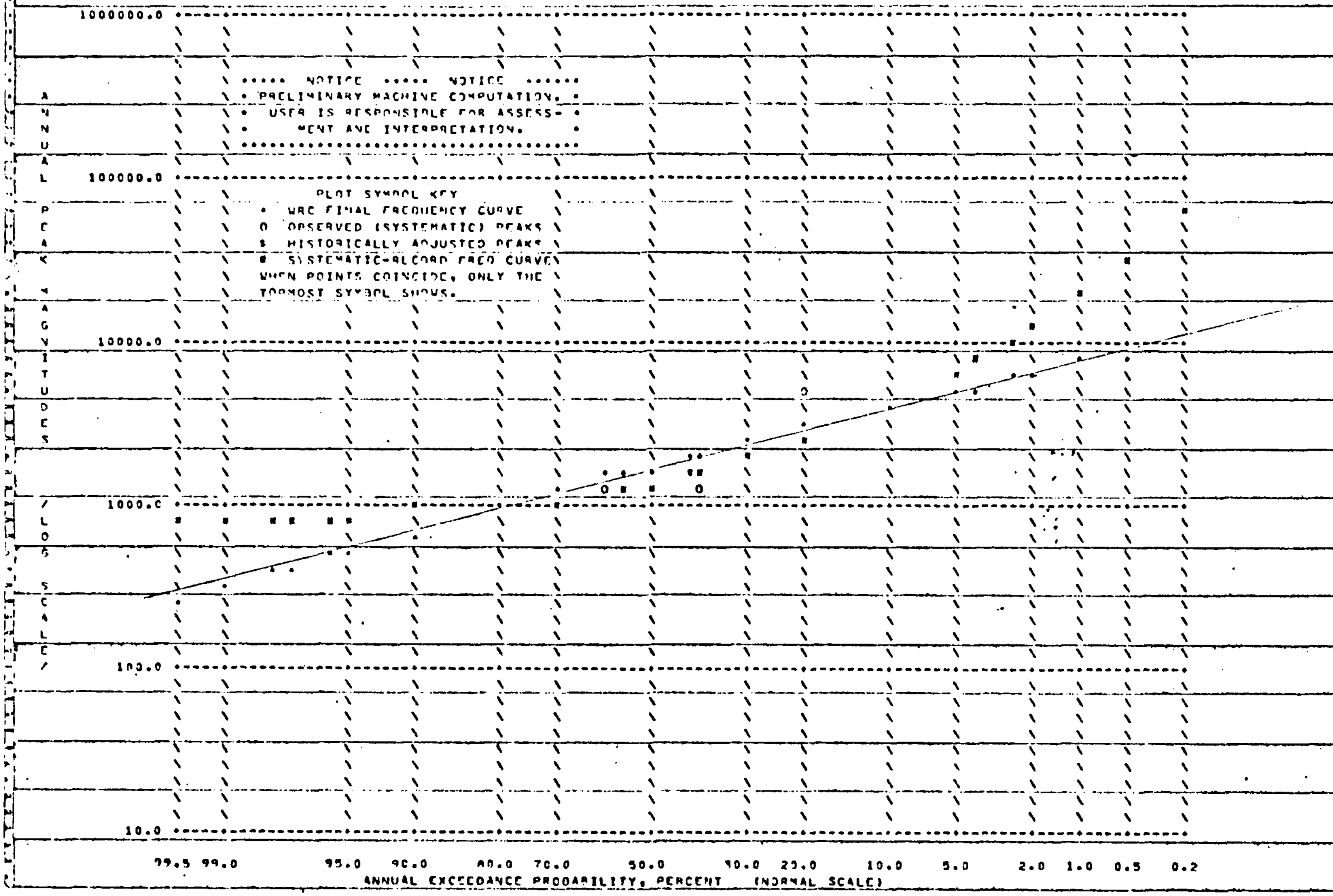
MODIFIED DIERKS

PGM J407 VER 3.4
(REV 10/22/79)

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

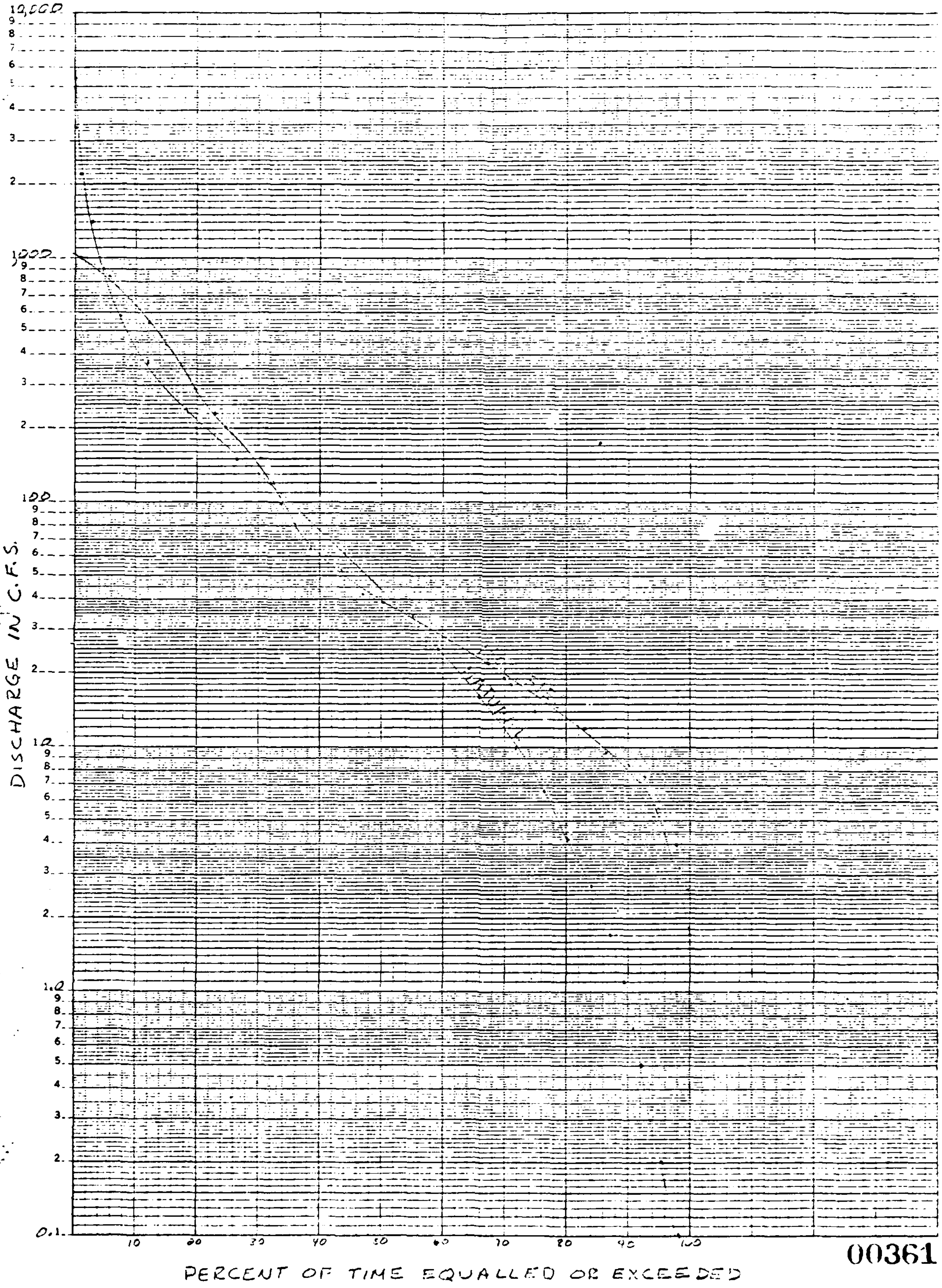
FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 3/80 AT 1453 SEQ 1.0001

STATION - 07341000/USGS SALINE RIVER NEAR DIERKS, ARK. 1975-1978 07341000/USGS



00360

DIERKS - SALINE R.



00361

K•E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN USA
46 6213

1. Project Name: Millwood Lake

2. Project Location: River mile 16.0 on Little River tributary to Red River. Project watershed (4,144 square miles) located in Arkansas; downstream management control stations located in Arkansas.

3. Type of Project:

a. General Category: multiple-purpose storage reservoir (exluding hydropower).

b. Storage Allocations:

	Elevation (feet, N.G.V.D.)	Storage Acre-feet	Storage Inches of Runoff
Top Flood Control Pool	287.0	1,354,930	8.39
Top Conservation Pool	259.2	153,260	.69
Bottom Conservation Pool	252.0	51,170	.23
Water Supply Storage (265 mgd)		150,000	

4. Water Management Criteria:

a. Authorized Project Purpose: flood control, water supply and fish and wildlife.

b. Water Use Contracts: water storage - 265 mgd.

c. Interagency Agreements: Minimum low flow release schedule with EPA

d. Informal Commitments: None

e. System Regulation Objectives: The project is regulated in the system to control floods and retain equivalent flood control capabilities with other projects in the system.

5. Project Evaluation:

a. Effects of impoundment on water stored:

1. Positive effects:

a. Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. On a long-term basis, the lake decreases nitrates, phosphates, and suspended heavy metals in the stream.

b. Quantity: The lake provides storage for flow augmentation in times of drought.

2. Negative effects:

a. Quality: Due to the basin morphometry, Millwood stratifies only occasionally. Such weak and ephemeral stratification is not associated with water quality degradation.

6. Project Effect on Instream Flows:

1. General: The estimated natural frequency curve is attached. The frequency and duration curve for modified conditions are also attached.

2. Positive effects: None known.

3. Negative effects: None known.

4. Project effects on system regulation: The project has a major influence on flood control of the Red River system.

7. Alternatives:

a. Reservoir Regulation: None

b. Structural Modification: None

c. Storage Reallocation: None

d. Other: No action

8. Action Taken to Date: None

9. Planned Action: None

MILLWOOD
LITTLE RIVER, ARKANSAS

Top of Conservation (Power) Pool Elevation	259.2
Top of Flood Control Pool Elevation	287

OUTLET WORKS

Type	Sluice
Size	2-5.67'x6'
Intake Elevation	223
Control Gates	2-5.67'x6'
Capacity at Conservation Pool (c.f.s.)	2800
Capacity at Flood Control Pool (c.f.s.)	3630

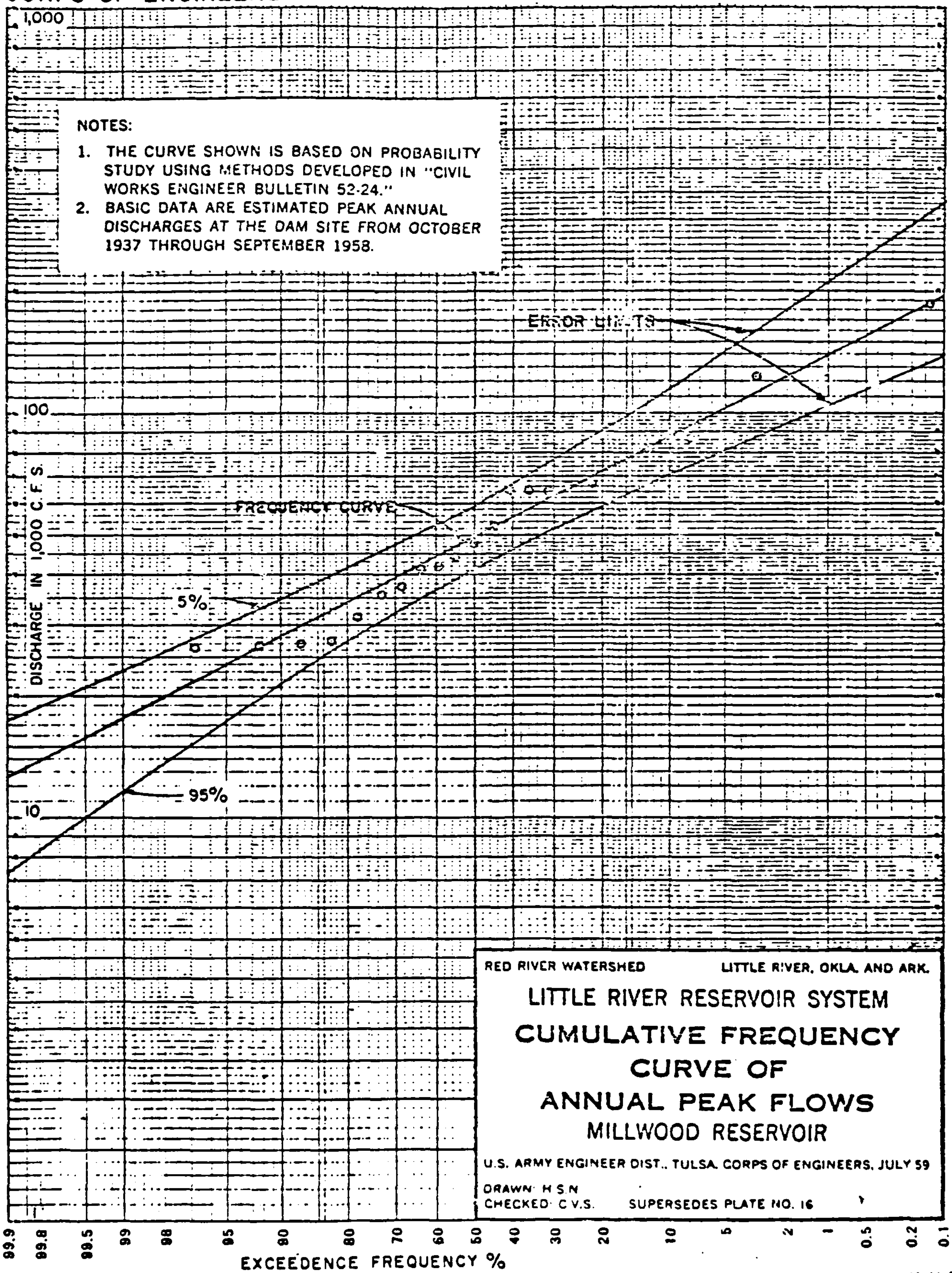
WATER SUPPLY FACILITY

Static Head Pipe	
Diameter	6.5' Dia.
Elevation	243

SPILLWAY

Type	Ogee
Crest Width	520'
Crest Elevation	255
Control	13-40'x32' (Tainter Gates)
Capacity at Conservation Pool (c.f.s.)	14,000
Capacity at Flood Control Pool (c.f.s.)	330,000

CORPS OF ENGINEERS U.S. ARMY



NOTES:

1. THE CURVE SHOWN IS BASED ON PROBABILITY STUDY USING METHODS DEVELOPED IN "CIVIL WORKS ENGINEER BULLETIN 52-24."
2. BASIC DATA ARE ESTIMATED PEAK ANNUAL DISCHARGES AT THE DAM SITE FROM OCTOBER 1937 THROUGH SEPTEMBER 1958.

RED RIVER WATERSHED LITTLE RIVER, OKLA. AND ARK.

LITTLE RIVER RESERVOIR SYSTEM

CUMULATIVE FREQUENCY CURVE OF ANNUAL PEAK FLOWS

MILLWOOD RESERVOIR

U.S. ARMY ENGINEER DIST., TULSA. CORPS OF ENGINEERS. JULY 59

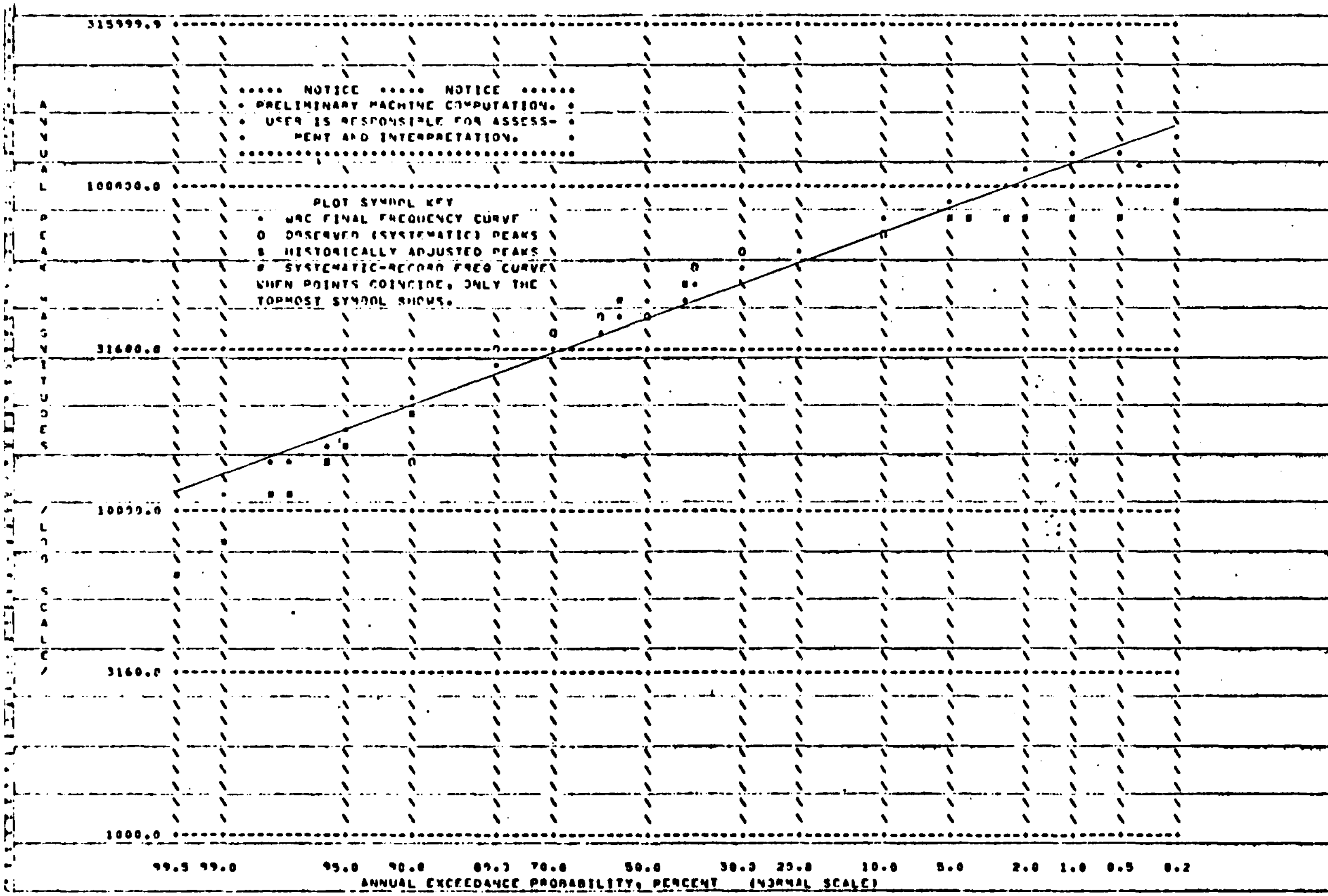
DRAWN: H.S.N.
CHECKED: C.V.S. SUPERSEDES PLATE NO. 16

(GM J407 VER 3.4
(REV 10/22/79)

U. S. GEOLOGIC[illegible] [illegible]VEY
ANNUAL PEAK FLOW FRE[illegible] [illegible]Y ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

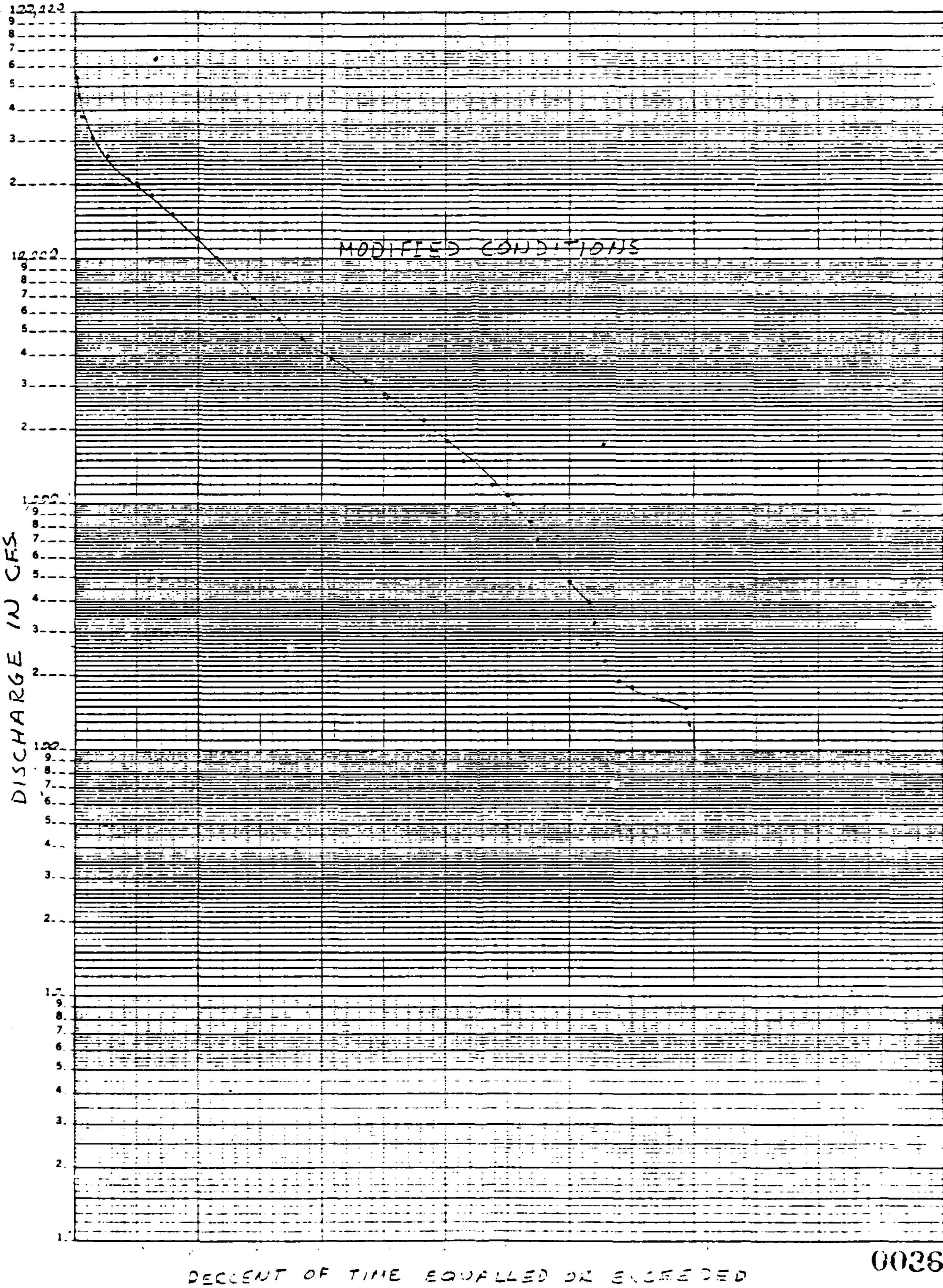
FREQUENCY STUDY OF ANNUAL PEAKS
RUN-DATE 11/ 3/80 AT 1550 SEQ 1.0001

STATION - 07341301/USGS LITTLE RIVER AT MILLWOOD DAM NR ASHDOWN, ARK. 1967-1975 07341301/USGS



00366

MILLWOOD - LITTLE R.



00267

WRIGHT PATMAN LAKE, TEXAS

1. Project Name: Wright Patman Lake and Dam (Texarkana Reservoir).

2. Project Location: River mile 44.5 on the Sulphur River, tributary to Red River. The project watershed (3,443 square miles) is located in the State of Texas and the downstream water management control stations are located in Texas and one in Louisiana.

3. Type of Project:

a. General Category: Multiple-purpose storage lake (excluding hydropower).

b. Storage Allocations and Other Pertinent Data: See Exhibit 1. The total storage below the top of conservation pool, elevation 220.0 feet n.g.v.d., is approximately 145,300 acre-feet. Of this approximately 68,000 acre-feet is allocated for sediment accumulation and approximately 77,300 acre-feet is allocated for water supply. See paragraph 4b for water supply use contracts.

c. Hydropower Category: N/A

4. Water Management Criteria:

a. Authorized Project Purposes: Flood control, water conservation and recreation by 711 program.

b. Water Use Contracts: Wright Patman has water supply contracts somewhat different from any others in the Fort Worth District. The contracts do not provide for a volume storage space, but for a maximum daily allowable usage by the sponsor. Second, water supply is derived by allocating some of the flood control storage to water supply storage on a seasonal basis.

(1) Contract No. DA-16-047-ENG-2033, 28 May 1953, was approved by the Secretary of the Army on 16 February 1954. This initial contract provides storage space for an average annual yield of 13 million gallons per day (Mgal/d). Seasonal withdrawals vary between 9.8 and 17.9 Mgal/d. The Cities of Texarkana, Texas and Arkansas began withdrawing water under this contract in December 1958.

LOCATION:
R.M. 44.5 on Sulphur River of the Red River, River Basin about 9 miles Southwest of Texarkana, Arkansas-Texas

DRAINAGE AREA:

3,400 square miles	
One inch of runoff	181,333 ac-ft

DAM:

Type:	Rolled earth fill
Length:	18,500' (including spillway)
Maximum Height:	106.0'
Top Width:	30'

SPILLWAY:

Crest Elev.	259.5
Length:	200.0'
Type:	Chute-type with ogee weir

INFLOW:

Spillway design flood peak, c.f.s.	451,000
Spillway design flood volume, ac-ft	3,645,000
Spillway design flood runoff, inches	20.1

OUTFLOW:

Total routed peak outflow, c.f.s.	63,200
Spillway	63,200
Outlet Works	0

OUTLET WORKS:

Type:	2-Gated conduits
Dimension:	20.0 - foot diameter
Invert Elev.	200.0
Control:	4-10'x20' hydraulically operated slide gates

Release Versatility: Controllable down to 10 c.f.s.

POWER FEATURE: None

Feature	Elev Feet *n.g.v.d.	Reservoir Area (acres)	Reservoir Capacity: Accumulative (ac-ft)	Runoff (inches)	Incremental ac-ft)	Spillway Capacity (cfs)	Outlet Works Capacity (cfs)
Top of Dam	286.0	234,100					
Maximum Design Water Surface	278.9	200,600	3,076,500	17.0		451,000	
Top of Flood Control Pool	259.5	119,700	2,509,000	13.8	2,363,700		27,600
Top of Conservation Pool	220.0	20,300	145,300	0.8	77,300		8,250
Sediment Reserve			68,000		68,000		
Streambed	180.0						

*The term n.g.v.d. refers to "National Geodetic Vertical Datum"

WRIGHT PATMAN LAKE

Exhibit 1

(2) Contract No. DACW29-68-A-0103, 16 April 1968, was approved by the Secretary of the Army on 11 July 1968. This contract provides for storage that allows for withdrawals at a rate of 13 Mgal/d under Contract No. DA-16-047-ENG-2033 plus an additional withdrawal of 143.0 Mgal/d for municipal and industrial water supply. This contract will not become effective until sometime after the completion of Cooper Dam. The Cooper Lake project will provide for the conversion of 120,000 ac-ft of flood control storage to water supply storage for fulfilling the requirements of Contract No. DACW29-68-A-0103.

(3) Contract No. DACW29-69-C-0019, 16 September 1968 was approved by the Secretary of the Army on 17 December 1968. This is an interim basis contract until Contract No. DACW29-68-A-0103 becomes effective. The interim contract provides for withdrawals of 13 Mgal/d as specified in Contract No. DA-16-047-ENG-2033 plus additional withdrawal not to exceed 84 Mgal/d.

c. Interagency Agreements: None.

d. Informal Commitments: None.

e. Systems Regulation Objectives: Wright Patman Lake and Dam is a multi-purpose project for flood control, water conservation and general recreation. In addition, it is part of the comprehensive plan for flood control on the Red River below Denison, Texas. Wright Patman Dam controls 12 percent of the Red River Basin below Denison Dam and approximately 91 percent of the Sulphur River above the confluence with the Red River. In the development of the plan of regulation for Wright Patman Lake, consideration was given to the following general requirements for reservoir operation:

(1) Limitation of reservoir release to a maximum of 10,000 c.f.s. for all floods of a lesser magnitude than the design flood.

(2) Minimize the duration of stages on the Red River at Shreveport, Louisiana, above 31 feet.

(3) Provision of minimum storage for water supply purposes in accordance with agreement with Cities of Texarkana, Arkansas, and Texas.

(4) Maintenance of a minimum release of 10 c.f.s. for low water flow in Sulphur River downstream from the dam.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: The chemical and bacteriological quality of the water in Wright Patman Lake is generally good. The impoundment tends to reduce the turbidity and suspended sediments associated with storm runoff. The long-term effect of the impoundment is to smooth out any sharp variations in chemical quality in the Sulfur River.

(b) Quantity: The impoundment tends to moderate the daily flow volumes passing the damsite by reducing the high flows. Planned operation of the project insures a more uniform streamflow during flood periods than would exist under natural conditions. The project has greatly increased the quantity available for beneficial uses such as water supply, lake recreation, and lake fishing.

(2) Negative effects: The data available indicates that the lake is well supplied with nutrients and is quite productive with occasional heavy growths of submerged and emergent vegetation. No nuisance conditions have been observed, however, and there is little or no impairment of the designated beneficial uses of the water. The project tends to develop a mild thermal stratification during the summer months. During this time the dissolved oxygen concentration in the hypolimnion tends to decrease to near zero at the bottom of the lake. That portion of the lake capable of supporting fish life for an extended period of time is limited to the top 20 to 25 feet of depth during the period of greatest stratification and dissolved oxygen depletion.

(3) Cause of negative effects: The domestic wastewater treatment plant discharges into the upstream tributaries plus the non-point source runoff contributes the nutrient loadings of nitrogen and phosphorus to the lake. The thermal stratification pattern and the aerobic decomposition of organics causes the decrease in dissolved oxygen in the hypolimnion waters during the summer months. Any variance in the chemical constituents in the inflow waters will also cause variations in the quality of the lake waters.

b. Project Effects on Instream Flows:

(1) General: Monthly flow volume frequency and duration curves for the flows immediately downstream of the project under pre- and post-impoundment conditions are shown on Plates 1 through 24. It should be noted that the periods of record are different.

(2) Positive effects: Wright Patman Lake generally tends to smooth the flood waters of the Sulfur River passing the project site and tends to reduce the downstream flood damages. The project tends to smooth any variances in the chemical quality of the Sulfur River. The chemical and bacteriological quality of the release waters is generally good. The project has generally increased the mean monthly flow volumes passing the damsite except during the spring and early summer months. The plan of regulation calls for the maintenance of a minimum release of 10 c.f.s. for low water flow in the Sulfur River downstream from the dam. During the period 17 May through 31 October the minimum releases will be 96 c.f.s. except when special instructions are issued for mosquito control. These minimum flows have been sufficient for sustaining a good downstream fishery.

(3) Negative effects:

(a) Quality: The available data indicates that the dissolved oxygen concentration in the release waters is depressed, especially during the summer months. Chemical analyses indicate that total and dissolved iron concentrations and manganese concentrations occasionally exceed the EPA's "Quality Criteria for Water". Under low-flow conditions the lower Sulfur River Basin acts as a slack water area in which there is no appreciable physical aeration causing a greater dissolved oxygen deficit in the stream water.

(b) Quantity: The mean monthly flow volumes passing the damsite during the late spring and early summer months has decreased. The project has also experienced downstream fish kills. The most extensive was in August 1966. These fish kills were attributed to regulation practices, that is the relatively rapid decrease in reservoir discharges.

(4) Cause of negative effects: Any degradation in the quality of the water directly below Wright Patman Lake can be attributed to the presence of the project, the subsequent thermal stratification of the

impounded waters, the quality of the inflow waters, and the introduction of degraded water by the International Paper Company and downstream tributaries. The fish kills experienced below the project have been attributed to the regulation practices used, at the time of the fish kills, that is, the relatively rapid decrease in reservoir discharge from 10,000 c.f.s. to 100 c.f.s. in 7 days. This practice has been discontinued. Fish kills attributed to regulation practices at Wright Patman Lake have been essentially non-existant since regulation procedures were modified to preclude such an event.

c. Project Effect on System Regulation: Wright Patman Lake and Dam is a multi-purpose project that is part of the comprehensive plan for flood control on the Sulfur River and the Red River below Denison, Texas. The project minimum releases of 10 c.f.s. for low flow in the Sulfur River helps insure a viable fishery year round and helps satisfy other downstream needs. The project has been operated in conformance with paragraph 4e.

6. Constraints on Obtaining Instream Quantity and Quality Objectives:

a. Quantity: The State of Texas claims the rights to the waters within the State of Texas. Historically the State has not required a minimum guaranteed release from Wright Patman Lake for the enhancement of the downstream fishery and the water use permits to the Cities of Texarkana, Texas and Arkansas have not specified such a release. Any attempt to increase minimum low flow releases would require changes to the permits.

(b) Quality: The Wright Patman Dam does not have a multiple-level selective withdrawal system for low flow releases. Therefore, the low flow releases must be made from the lower level, poorer quality water of the project.

7. Alternatives:

a. Reservoir Regulation: See paragraph 8.

b. Structural Modification: See paragraph 8.

c. Storage Reallocation: None proposed.

8. Actions Taken to Date: The Corps of Engineers has conducted meetings with the Arkansas Game and Fish Commission in order to evaluate

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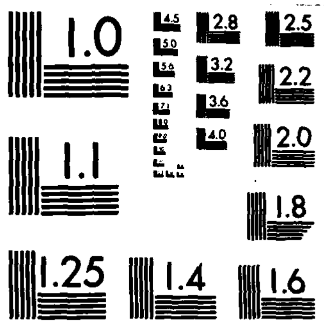

MICROCOPY RESOLUTION TEST CHART
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water quality problems downstream of the Wright Patman Dam and to determine the cause of the fish kills below the dam. A study was conducted and the report "A Preliminary Investigation of the Effects of Wright Patman Lake on Dissolved Oxygen in the Lower Sulfur River" completed. The report concludes that dissolved oxygen concentrations in the releases from Wright Patman Lake have met all applicable criteria from 1975 to 1977. The report investigated a structural modification, the placement of a skimmer weir to effectively skim the upper level waters from the lake for downstream releases, and concluded that the modification would not substantially improve the quality of the released water. The report also pointed out that downstream point and non-point sources of pollution hinder isolating the effects of Wright Patman releases 30 miles downstream. The problem of fish kills downstream of the project was addressed. The report determined that the fish kills were related primarily to regulation practices, that is, the relatively fast decrease in reservoir discharge: from 10,000 c.f.s. to 100 c.f.s. in 7 days. This practice has been discontinued and the change in release has been more gradual to allow for downstream environmental changes. Fish kills attributed to regulation practices at Wright Patman Lake have been essentially non-existent since regulation procedures were modified to preclude such an event.

9. Planned Actions: A meeting between the Fort Worth District, the Arkansas Game and Fish Commission and the New Orleans District to discuss the findings the report mentions in paragraph 8 and to determine the best corrective action with regards to the problems below the project is planned.

LAKE O' THE PINES, TEXAS

1. Project Name: Lake O' the Pines and Ferrells Bridge Dam

2. Project Location: River mile 81.2 on Cypress Creek, a tributary of the Red River. Project watershed of 880 (850) square miles is located in the State of Texas. The 880 square mile area was derived from the latest topographic maps while the 850 square mile area was used for design of the project and will be used for this report. Although there is no official water management station between the impoundment and the Red River, low flow releases are made to specified stages and discharges in Cypress Creek immediately below the dam in the State of Texas. Other releases are made at specified rates dependent upon pool elevation and rate of inflow, provided that such releases will be reduced to minimize the duration of stages above 31 feet in the Red River at Shreveport, Louisiana.

3. Type of Project:

a. General Category: Multiple-purpose storage reservoir (excluding hydropower).

b. Storage Allocations and Other Pertinent Data: See Exhibit 1. Approximately 1,100 acre-feet of the 251,100 acre-feet of storage below elevation 228.5 is reserved for conservation purposes with the remaining 250,000 acre-feet available for water supply and for continuous low flow releases for mesquito control.

c. Hydropower Category: N/A

4. Water Management Criteria:

a. Authorized Project Purposes: Flood control, water supply, recreation under the 711 program, and mesquito control (including downstream low flow augumentation).

b. Water Use Contracts: Contract with Northeast Texas Municipal Water District for 100 percent, or approximately 250,000 acre-feet, of the storage between elevations 201 and 228.5 for water supply purposes with a provision that the Government reserves the right to maintain a low flow release of 5 c.f.s. and under certain specified conditions during the months of May through October, low flow releases of more than 5 c.f.s.

c. Interagency Agreements: None.

d. Informal Commitments: None.

PERTINENT DATA

LAKE O' THE PINES

DRAINAGE AREA	sq mi	880*
CONSERVATION POOL		
Elevation	ft m.s.l.	201.0
Area	acre	1,100
Storage	Acre-ft	3,800
Equivalent runoff	in	0.1
WATER SUPPLY POOL		
Elevation	ft m.s.l.	228.5
Area	acre	18,700
Storage	acre-ft	251,100
Equivalent runoff	in	5.5
FLOOD CONTROL POOL		
Elevation	ft m.s.l.	249.5
Area	acre	38,200
Storage	acre-ft	587,200
Equivalent runoff	in	13.0
Regulated outflow	ft^3/s	3,000
Outlet capacity at pool elev. 249.5	ft^3/s	6,400
Design flood		
Estimated peak inflow	sfd	66,000
Design peak outflow	ft^3/s	3,000
Estimated volume	acre-ft	906,700
Equivalent runoff	in	20.0
SURCHARGE POOL		
Elevation	ft m.s.l.	269.9
Area	acre	63,200
Storage	acre-ft	1,013,900
Equivalent runoff	in	22.4
Design flood hydrograph		
Estimated peak inflow	ft^3/s	367,100
Estimated peak outflow	ft^3/s	68,200
Estimated volume	acre-ft	1,320,300
Average rainfall	in	30.0
Average runoff	in	29.1
FREEBOARD		
Elevation	ft m.s.l.	277.0
Area	acre	73,100
Storage	acre-ft	485,900
Equivalent runoff	in	10.7
Height	ft	7.1
LOW-FLOW OUTLET (VALVE CONTROLLED)		
Conduit, number and diameter		1-14"
Conduit intake invert elevation	ft m.s.l.	200.0
Discharge versatility	Controllable down to about one	c.f.s.
OUTLET STRUCTURE		
Conduits, number and diameter		2 - 10.0'
Gates, number and size		2 - 8' x 12.5'
Conduit intake invert elevation	ft m.s.l.	200.0
Conduit outlet invert elevation	ft m.s.l.	199.0
Tail water elevation for a discharge of 3,000 ft^3/s	ft m.s.l.	198.4
SPILLWAY		
Width	ft	200
Crest elevation	ft m.s.l.	249.5
Tail water elevation for a discharge of 68,200 ft^3/s	ft m.s.l.	214.4
DAM		
Elevation of crest	ft m.s.l.	277.0
Height above valley	ft	77
Length of crest	ft	10,600

*Recent maps indicate a drainage area of 880 square miles instead of the 850 square miles used in the design of the reservoir.

e. System Regulation Objectives: Lake O' the Pines is an integral part of a comprehensive plan for flood control in the Red River basin below Denison Dam (Lake Texoma). Lake O' the Pines, Wright Patman Lake and Lake Texoma are to be regulated as a system to achieve maximum flood control benefits along the Red River during critical flood periods. During other floods, Lake O' the Pines is to be regulated to reduce severe flooding between the dam and the Red River. Releases from the water supply storage and the seasonal recreation storage are to be made in accordance with the water supply contract, the water use permit granted by the State of Texas and the plan for low flow releases for mosquito control approved by the State of Texas.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects: The impoundment greatly increases the amount of water available for beneficial uses such as water supply, lake fishing and lake recreation. The impoundment serves as an effective sediment trap and the turbidity of inflowing flood water is decreased markedly in a fairly short period of time. Limited available data indicates that the quality of impounded water is generally good.

(2) Negative effects: A moderate degree of thermal stratification can usually be expected during June, July and August. During periods of thermal stratification, dissolved oxygen concentration in the hypolimnion is depressed and is zero or near zero near the bottom of impoundment. The concentrations of hydrogen sulfide and of dissolved iron and manganese in the hypolimnion can be expected to increase substantially during periods of thermal stratification.

(3) Cause of negative effects: The negative effects are attributed to the thermal stratification and natural chemical composition of the inflow water. Use of project lands and land use over the remainder of the project watershed are believed to have a minimal effect on the quality of stored water.

b. Project Effect on Instream Flows:

(1) General: Monthly discharge-frequency and flow duration curves for pre- and post-impoundment conditions at a point immediately downstream from the impoundment are shown on Plates 1 through 24. Note that the period of record for the two conditions are not the same.

(2) Positive effects: The impoundment has prevented or reduced damaging flooding between the dam and the Red River and reduced damaging flooding along the Red River, resulting in reductions in flood damages which would have occurred without the project. Minimum releases of 5 or 25 c.f.s. have sustained a significant fishery for native species and hybrid striped bass in the stream between the dam and the head of Caddo Lake. The minimum release of 25 c.f.s. applies whenever the pool is between elevations 228.5 and 230 during the period of 20 May - 15 September. The minimum release of 5 c.f.s. applies wl never the pool is below elevation 228.5. The quality of water released can be expected to be good when the impoundment is not thermally stratified.

(3) Negative effects: The impoundment has caused a general reduction in downstream low flow; however, the possible negative effect of this reduction on instream fishery flow needs has probably been largely ameliorated by the continuous minimum releases described in paragraph 5b(2). The flow duration curves on Plates 13 through 24 appear to indicate that post-impoundment monthly flows have been zero or near zero during significant percentages of time for the months of May through October; however, this is caused by small plotting and curve-drawing errors. Post-impoundment flows have never been less than 272 acre-feet per month which is equivalent to a flow rate of 4.5 c.f.s. continued for one month. Water released from the impoundment when it is thermally stratified can be expected to exhibit a low dissolved oxygen concentration and possibly a hydrogen sulfide odor and increased levels of dissolved iron and manganese.

(4) Cause of negative effects: Any degradation in the quality of water released can be attributed to thermal stratification of the impoundment and the fact that all releases must be made from the poorer quality water in the hypolimnion. Degradation in the quantity of water released, if any, can be attributed to inadequate provisions in the water use permit granted by the State of Texas and in the water use contract described in paragraph 4b.

c. <u>Project Effects on System Regulation</u>: Lake O' the Pines has been operated in conformance with the system regulation objectives specified in paragraph 4e.

6. <u>Constraints on Obtaining Instream Quantity and Quality Objectives</u>:

a. <u>Quantity</u>: The State of Texas has not requested water to be released from the impoundment for fish and wildlife purposes; however, they have stressed the importance of not reducing the minimum releases

described in paragraph 5b(2). There are no provisions in the existing water supply contract or water use permit for additional releases to improve the downstream fishery.

b. Quality: There is no multiple-level selective withdrawal system for the outlet works or the low-flow outlet of the dam; therefore, all releases must be drawn from the poorer quality hypolimnion water when the impoundment is thermally stratified.

7. Alternatives:

a. Reservoir Regulation: No changes proposed.

b. Structural Modifications: None proposed.

c. Storage Reallocation: None proposed.

d. Other: None proposed.

8. Actions Taken to Date: Lake O' the Pines is considered to have satisfactory low flow releases, therefore, no recent actions have been taken to possibly improve the low flow conditions downstream from the project.

9. Planned Activities: None.

SAM RAYBURN RESERVOIR, TEXAS

1. Project Name: Sam Rayburn Dam and Reservoir

2. Project Location: River mile 25.2 on the Angelina River, tributary to Neches River. The project watershed (3,449 square miles) is located in the State of Texas and the downstream water management control stations are located in Texas.

3. Type of Project:

a. General Category: Multiple-purpose storage reservoir (including hydropower).

b. Storage Allocations and Other Pertinent Data: See Exhibit 1. A total of 2,898,100 acre-feet of storage has been provided in Sam Rayburn Reservoir below elevation 164.4. Of this amount 1,446,100 acre-feet (between elevations 149.0 and 164.4) are assigned to hydroelectric power development and stream-flow regulation, 1,452,000 acre-feet are for power head and sediment storage, and 43,000 acre-feet are for municipal and industrial water supply for the City of Lufkin, Texas. In order to supply water for municipal, industrial, and agricultural uses, it is necessary to provide for a flow varying from a minimum of about 300 second-feet to a maximum of about 1,800 second-feet during the months of maximum water demand (June, July, and August) for rice culture. In addition it is desirable to maintain a continuous flow in the lower river to dilute and flush out sewage and industrial wastes and to prevent salt water from encroaching as far upstream as the water supply diversions.

c. Hydropower Category: Peak demands hydroelectric generation.

4. Water Management Criteria:

a. Authorized Project Purposes: Flood control, hydroelectric power, stream regulation, fish and wildlife, and recreation by 711 program.

b. Water Use Contracts:

(1) Contract No. DA-41-443-CIVENG-57-20 with LNVA and Contract No. 14-02-0001-1124 with Sam Rayburn Dam Electric Cooperative, Inc. Under the terms of these contracts the Government agrees, to the extent that water is available in the reservoir above elevation 149.0, to make releases of water from Sam Rayburn as required for the generation of power. The releases will be at least sufficient to generate

LOCATION: R.M. 25.2 on Angelina River, Neches River Basin, 10 miles northwest of Jasper, Jasper County, Texas.

DRAINAGE AREA:
3,449 square miles
One inch of runoff - 183,947 acre-feet

DAM:
Type: Earth fill
Length: 19,430' (including spillway and dikes)
Maximum Height: 120'
Top Width: 42'
Dikes: 10'

SPILLWAY:
Crest Elevation: 176.0
Length: 2,200' net at crest
Type: Broadcrested weir (cellular type)
Control: Uncontrolled

INFLOW:

Spillway design flood peak, cfs	395,600
Spillway design flood volume, ac-ft	3,784,700
Spillway design flood runoff, inches	20.57

OUTFLOW (Elevation 183.0):

Total routed peak outflow, cfs	147,400
Spillway	125,300
Outlet works	22,100

OUTLET WORKS:
Type: 2 conduits
Dimension: 10'x20'x180'
Invert Elevation: 105.0
Control: 2-10'x20' tractor type gates (plus 1 emergency tractor type gate)
Release Versatility: Controllable down to approximately 20-30 cfs

POWER FEATURES:
Number of units: 2
Penstocks size: 10'x28'
Invert Elevation: 105.0
Capacity (combined): 8,800 cfs

Feature	Elev Feet (msl)	Reservoir Area (acres)	Reservoir Capacity: Accumulative (ac-ft)	Reservoir Capacity: Runoff (inches)	Reservoir Capacity: Incremental (ac-ft)	Spillway Capacity (cfs)	Outlet Works Capacity (cfs)
Top of dam	190.0						
Maximum design water surface	183.0	180,000	5,610,000	30.50		125,300	22,100
Spillway crest	176.0	153,800	4,442,400	24.15		0	
Top of flood control pool	173.0	142,700	3,997,600	21.73	1,145,000		22,000
Top of power pool	164.4	114,500	2,898,100	15.75	1,446,100		20,000
Top of power head and sediment storage	149.0	74,040	1,452,000	7.89	1,452,000		
Total storage					4,043,100		
Maximum tailwater	121.5						
Streambed	70.0						

(IN OPERATION)

SAM RAYBURN DAM AND RESERVOIR

00381

power equivalent to 42,400 kilowatts for a minimum period of 75 hours per month for each of the six-month periods from mid-April through mid-October of each year. Sam Rayburn releases will be re-regulated by the B. A. Steinhagen Lake downstream; and the Authority will be permitted to order releases from B. A. Steinhagen subject to the provisions of Section 104, Public Law 858, 80th Congress.

(2) Contract No. DACW63-69-C-0007, dated 27 May 1969, gives the City of Lufkin, Texas, the rights to 18,000 acre-feet of storage space between elevations 149.0 and 164.4 for present use water supply, and to an ultimate use space of 43,000 acre-feet.

c. Interagency Agreements: None

d. Informal Commitments: None

e. System Regulation Objectives: Within the Angelina River and Neches River Basin, there are two existing Corps of Engineers projects: B. A. Steinhagen Lake and Sam Rayburn Reservoir. There is no flood storage in B. A. Steinhagen Lake. Thus Sam Rayburn Dam is responsible for flood control within the basin and for hydropower generation. The primary function of B. A. Steinhagen Lake as related to the system is to re-regulate the power releases from Sam Rayburn Reservoir, thereby reducing the fluctuating stages downstream on the Neches River.

5. Project Evaluation:

a. Effect of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: The impoundment of water behind Sam Rayburn Dam tends to reduce any turbidity associated with storm runoff waters and is responsible for trapping some sediment and nutrients. Analysis of water quality constituents monitored since deliberate impoundment indicates that the present quality of water in Sam Rayburn Reservoir is generally good. The impoundment tends to improve the quality of the poor quality inflow waters. The wide variations in some of the levels of inflow quality constituents are smoothed out by the impoundment.

(b) Quantity: The impoundment tends to smooth out the peak flood flows in the Angelina River. The impoundment is used for flood storage, irrigation water storage, and hydropower generation. The project has greatly increased the water available for beneficial purposes such as water supply, recreation, and lake fishing.

(2) Negative effects: Temperature stratification normally exists in Sam Rayburn Reservoir from March through September. The intensity of the stratification is usually greatest during the months of June, July, and August with a peak differential of 15° to 20° F. The creation of an oxygen deficit in the hypolimnion during the summer months is a usual occurrence. By mid-summer, dissolved oxygen concentrations in the bottom of the reservoir approach zero, levels too low to support a significant amount of aerobic decomposition or to support fish. During the summer months that portion of the reservoir capable of supporting most fish and invertibrate life is reduced to the top 20-25 feet. Analysis of available data indicates that the upstream end of the lake contains poor quality water, especially during the summer months. The concentrations of dissolved oxygen, chlorides, sulfates, and the pH are often outside the recommended limits of the Texas Water Quality Standards.

(3) Causes of negative effects: The poor quality of the water of the upstream tributaries to the Angelina River is the major contributor to the degradation of the water in the upper reach of Sam Rayburn Reservoir. This is mainly due to the wastewater effluents of the municipal treatment plants and paper mills upstream of the reservoir. The thermal stratification pattern of the impounded waters is the main cause of any variance in the quality of the main reservoir area water. The majority of the conservation and power releases are made upon request and are thus the cause of any pool elevation and tailwater fluctuations.

b. Project Effects on Instream Flows:

(1) General: Monthly flow volume frequency and duration curves for flows at a point immediately downstream of the project under pre- and post-impoundment conditions are shown on Plates 1 through 24. It should be noted that the periods of record for the two conditions are not the same. The power facilities at the project includes two generation units. The facilities generate on demand to meet peak load power demands and therefore may or may not use both units at one time. The average monthly hours of part load generation for the period 1970 to 1980 was 361 hours. The outlet works of Sam Rayburn Dam consists of the penstocks and the flood control conduit. There is no separate low-flow outlet works. Since the power demand is variable it is possible to operate the power plant at higher load factors during the months of peak water demand for rice production and at lower load factors during the remainder of the year. Thus, the release requirements for power and irrigation are satisfied with releases through the turbines.

(2) Positive effects: The operation of the reservoir, primarily for flood control and power production, has reduced the magnitude of high flows and associated downstream damages, and generally has increased the level of low flows of the Angelina River downstream from the reservoir. This increase in low-flow volumes has helped meet instream maintenance flows downstream of the project. Regulation of flow has reduced greatly the variations in concentrations of most dissolved constituents and has resulted in a more uniform quality of water downstream.

(3) Negative effects: Analysis of the project release waters indicates that the quality of the releases is occasionally outside of the Texas Water Quality Standards, especially during the summer months. The data indicates that the dissolved oxygen concentration is often below the 5.0 mg/l standard, especially during power releases in the summer. Of the 126 test samples 18 were below the recommended limits with the samples ranging from 1.4 mg/l to 13.6 mg/l with a mean value of 8.0 and a standard deviation of 2.7 mg/l. A hydrogen sulfide odor is often experienced with the power releases, especially during the late summer months. The concentrations of chlorides, sulfates, dissolved solids and pH of the release waters were similarly found to be outside the recommended limits. The pH ranged from 5.6 to 7.8 with a mean of 6.8, a standard deviation of 0.4, and 28 of 181 samples below the recommended limits of 6.5 to 8.5. The chloride concentration ranged from 8 to 195 mg/l with a mean of 33 mg/l, a standard deviation of 33.3 mg/l, and 15 of 180 samples exceeding the standard of 70 mg/l. The sulfate concentration ranged from 9 mg/l to 55 mg/l with a mean of 22 mg/l, a standard deviation of 9 mg/l, and 10 of 177 samples exceeding the standard of 40 mg/l. The dissolved solids concentration ranged from 46 mg/l to 453 mg/l with a mean of 127 mg/l, a standard deviation of 71 mg/l, and 12 of 177 samples exceeding the recommended 250 mg/l. Since power releases are made upon demand there are sudden variances in the tailwater and downstream flow volumes.

(4) Cause of negative effects: Any degradation in the quality of the water directly below Sam Rayburn Dam can be attributed to the presence of the dam, the thermal stratification of the impounded waters, and the lack of a multiple level low-flow release capability of the project. Since the project can only release low-flows through the power turbines releases are from the poorer quality hypolimnetic waters. The power releases are made upon demand and are thus the cause of the sudden fluctuations in tailwater and downstream flows.

c. <u>Project Effects on System Regulation</u>: Sam Rayburn Dam and Dam B were constructed for the control of floods and the utilization

of the Neches River Basin water resources for the development of hydroelectric power, for water conservation, and for other related beneficial uses. Sam Rayburn Reservoir contains storage for flood control and power generation. Since the rapidly fluctuating release rates from Sam Rayburn Dam are made upon request and the release waters are from the hypolimnetic poorer quality water of the reservoir the coordinated operation of Dam B and Sam Rayburn Dam is necessary. The coordinated operation of the projects smooths out the variances in both the water quality constituents and the stages downstream on the Neches River.

6. Constraints on Obtaining Instream Quality and Quantity Objectives: The quality of the inflow waters is poor causing the quality of the impounded waters to be degraded especially during the summer months. Since the project lacks a multiple level withdrawal system for low-flow releases, the conservation storage releases are made from the poorer quality hypolimnion waters. The sudden fluctuations in tail-water and downstream flows are due to the power production operations.

7. Alternatives:

a. Reservoir Regulation: A study is in progress to update the operating rule curve for the project. Once complete any changes will be incorporated in a new regulation plan.

b. Structural Modification: See paragraph 8.

c. Storage Reallocation: None proposed.

8. Actions Taken to Date: The Fort Worth District has conducted three meetings with the U. S. Fish and Wildlife Service in connection with flow maintenance downstream of the Fort Worth District projects. Inasmuch as the U. S. Fish and Wildlife Service agrees with the Fort Worth District's assessment that releases from Sam Rayburn Dam are satisfactory, no additional study for flow maintenance will be conducted. The Fort Worth District, however, is in the process of determining the best means for alleviating the dissolved oxygen problem associated with the releases, especially during the summer power releases, from the project. The study will investigate possible structural modifications and the use of deflector plate aeration. The use of a skimming weir to draw water from the top 10 to 15 feet of the lake during power releases has been investigated. Data available indicates that with a fluctuating power pool such as at Sam Rayburn Reservoir this method may not be the most feasible. The use of a deflector plate aeration method has proven effective and is being given further consideration. The initial cost for a deflector plate aeration system is estimated to be about $60,000.

9. Planned Actions: See paragraph 8.

B. A. STEINHAGEN LAKE, TEXAS

1. Project Name: B. A. Steinhagen Lake (Town Bluff) (Dam B)

2. Project Location: River mile 113.7 on the Neches River. The project watershed (7,573 square miles) is located in the State of Texas and the downstream water management control stations are located in Texas.

3. Type of Project:

a. General Category: Multiple-purpose storage lake (including hydropower).

b. Storage Allocations and Other Pertinent Data: See Exhibit 1.

c. Hydropower Category: None at present. Construction has been deferred until justified by future conditions.

4. Water Management Criteria:

a. Authorized Project Purposes: Flood control, water supply, recreation by 711 program, and hydroelectric power.

b. Water Use Contracts: Public Law 858 provides that the sponsoring agency, the Lower Neches Valley Authority, will be permitted to withdraw from B. A. Steinhagen Lake not to exceed 2,000 c.f.s. for its own use.

c. Interagency Agreements: None.

d. Informal Commitments: None.

e. System Regulation Objectives: Within the Angelina River and Neches River Basin, there are two existing Corps of Engineers projects: B. A. Steinhagen Lake and Sam Rayburn Reservoir. There is no flood storage in B. A. Steinhagen Lake. Thus Sam Rayburn Dam is responsible for the flood control within the Neches River Basin and the primary function of B. A. Steinhagen Lake as related to the system is to re-regulate the power releases from Sam Rayburn Reservoir, thereby reducing the fluctuating stages downstream on the Neches River.

5. Project Evaluation:

LOCATION: R.M. 113.7 on the Neches River, 12 miles below the mouth of the Angelina River, 1/2 mile north of Town Bluff, TX, and 93 river miles north of Beaumont, TX.

DRAINAGE AREA:
7.573 square miles
One inch of runoff - 403,893 acre-feet

DAM:
Type: Paved earth fill
Length: 6,698' (including spillway)
Maximum Height: 45'
Top Width: 25'

SPILLWAY (GATED):
Crest Elev: 50.0
Length: 240'
Type: Ogee
Control: 6-40'x35' tainter gates

SPILLWAY (UNCONTROLLED):
Crest Elev: 85.0
Length: 6,100'

LOW-FLOW OUTLETS:
Type: 2-4'x6' conduits in right abutment of spillway
Invert Elev: 52.0
Release versatility: Control down to approximately 10 c.f.s.

POWER FEATURES:
None at present. Construction deferred until justified by future conditions.

Feature	Elev Feet (msl)	Reservoir Area (acres)	Reservoir Capacity: Accumulative (ac-ft)	Reservoir Capacity: Runoff (inches)	Reservoir Capacity: Incremental (ac-ft)	Spillway Capacity (cfs)	Low-Flow Outlets Capacity (cfs): 1 Sluice	Low-Flow Outlets Capacity (cfs): 2 Sluices
Top of dam	95.0							
Maximum design water surface	93.0	28,210	306,400	0.76		218,300		
Top of gates and uncontrolled spillway	85.0	16,830	124,700	0.31	None	80,000	800	1,540
Normal pool (upper)	83.0	13,700	94,200	0.23	77,300	67,000	775	1,490
Normal pool (lower)	81.0	10,950	69,700	0.17	(53,100)	54,400	750	1,440
Invert of sluice intake	52.0	20	20	0		300	0	0
Gate sill and streambed	50.0	0	0	0		0	0	0
Sediment reserve					16,600			
Total storage					94,200			

(IN OPERATION)

TOWN BLUFF DAM - B. A. STEINHAGEN LAKE

(May 1977)

Exhibit 1

00387

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: The impoundment of water behind Dam B tends to reduce any turbidity associated with storm runoff waters and the structure is responsible for trapping some sediment and nutrients. Analysis of existing data indicates that the quality of the inflow waters from the Neches River and the Angelina River is not always in compliance with the applicable Texas Water Quality Standards. The impoundment of the inflow water tends to reduce the variations in concentrations of most of the dissolved constituents. The data indicates that the quality of the impounded water is generally good.

(b) Quantity: The impoundment re-regulates the daily fluctuation in discharge of the upstream tributaries and has increased the quantity available for such beneficial uses as irrigation, municipal water supply, lake recreation, and lake fishing.

(2) Negative effects: Temperature stratification normally exists in B. A. Steinhagen Lake from April or May through September. The mild stratification pattern experiences the greatest intensity during the months of June, July, and August with a peak differential of 8° to 15° F. The dissolved oxygen concentration near the bottom of the lake tends to approach zero during the summer months. The existing data indicates that the fecal coliform count has occasionally exceeded the recommended Texas Water Quality Standards during the summer months. This is probably due to the unsewered residential development near the lake and discharges of untreated domestic wastes which have been reported in the vicinity of the lake.

(3) Cause of negative effects: The pool fluctuation is caused by the fluctuation in the power releases from Sam Rayburn Dam. The degradation of the impounded water is due to the thermal stratification pattern of the impounded waters and the unsewered residential waste runoff in the watershed.

b. Project Effects on Instream Flows:

(1) General: Monthly flow volume frequency and duration curves for flows immediately downstream of the project under pre- and post-impoundment conditions are shown on Plates 1 through 24. It should be noted that the periods of record for the two conditions are not the same.

(2) Positive effects: The Dam B project tends to smooth out the rapidly fluctuating stages of the Neches River by re-regulating the power releases of Sam Rayburn Dam. The project provides storage for municipal water supply and irrigation waters. The releases from the project generally tend to satisfy the below project instream maintenance flow needs. The limited data available on the quality of the water below Dam B indicates that the water is generally of good quality.

(3) Negative effects: Analysis of the project releases indicates that the quality of the releases is occasionally outside of the Texas Water Quality Standards, especially during the summer months. The data indicates that the dissolved oxygen concentration ranged from 4.4 mg/l to 11.0 mg/l with an average of 7.8 mg/l, a standard deviation of 1.5 mg/l, and 3 of 86 samples being outside the standards. Of the 16 fecal coliform counts taken, 3 were outside the 200/100 ml standard. The counts ranged from 1/100 ml to 1410/100 ml with a geometric mean of 27/100 ml. Of the 62 samples tested for sulfide only 1 was outside the 30 mg/l standard. The samples range from 5 mg/l to 33 mg/l with an average of 17 mg/l.

(4) Causes of negative effects: Any degradation in the quality of the water directly below Dam B can be attributed to the presence of the dam, the thermal stratification pattern of the impounded waters, and the lack of a multiple level low-flow release system. Since the project can only release low-flows from one level the quality of the releases cannot be controlled.

c. Project Effects on System Regulation: Dam B and Sam Rayburn Dam were constructed for the control of floods and the utilization of the Neches River Basin water resources for the development of hydro-electric power, for water conservation, and for other related beneficial uses. Sam Rayburn Reservoir contains the storage for flood control and hydropower generation. The releases from Sam Rayburn Dam are made upon request and may cause rapid fluctuations in downstream stage. The coordinated operation of Dam B re-regulates the fluctuating flows from Sam Rayburn Dam and smooths the variance in both the water quality constituents and the stages downstream on the Neches River.

6. Constraints on Obtaining Instream Quantity and Quality Objectives: The quality of the inflow waters is not always in compliance with the recommended Texas Water Quality Standards. During the summer months this condition is accentuated by the thermal stratification pattern within B. A. Steinhagen Lake. Since low-flow releases can only be made

from one level the downstream waters may be adversely effected. Fluctuations in Sam Rayburn Dam releases may cause minor fluctuations in the releases from Dam B. The releases can only be controlled down to about 10 c.f.s. and higher rates controlled within plus or minus 5 c.f.s.

7. Alternatives:

a. Reservoir Regulation: None proposed.

b. Structural Modification: None proposed.

c. Storage Reallocation: None proposed.

8. Actions Taken to Date: The Fort Worth District has conducted three meeting with the U. S. Fish and Wildlife Service in connection with flow maintenance downstream of the Fort Worth District projects. Inasmuch as the U. S. Fish and Wildlife Service agrees with the Fort Worth District assessment that releases from Dam B are satisfactory, no additional study for flow maintenance is planned.

9. Planned Actions: None proposed.

BENBROOK LAKE, TEXAS

1. Project Name: Benbrook Lake

2. Project Location: R.M. 15 on Clear Fork of Trinity River. Project watershed of 429 square miles and downstream water management stations are located in the State of Texas.

3. Type of Project:

a. General Category: Multiple-purpose storage reservoir (including navigation but excluding hydropower).

b. Storage Allocations and Other Pertinent Data: See Exhibit 1. Approximately 15,750 acre-feet of the 88,248 acre-feet of storage below the top of conservation pool is reserved for sediment accumulation with the remaining 72,498 acre-feet available for navigation purposes. Approximately 33.8 percent, or 24,483 acre-feet, of the conservation storage between elevations 665 and 694 has been contracted for water supply purposes and for releases to satisfy downstream riparian and/or appropriative rights until such time as this storage is needed for navigation. The remaining 48,015 acre-feet of navigation storage is available for downstream flow control so long as this storage is not needed for navigation purposes nor for water supply purposes as evidenced by water supply contracts with the City of Fort Worth, the Benbrook Water and Sewer Authority and/or the City of Arlington.

c. Hydropower Category: Not applicable.

4. Water Management Criteria:

a. Authorized Project Purposes: Originally, flood control, navigation and allied purposes with stipulation that "should the navigation project be not constructed, this storage (the navigation storage) may be utilized to advantage for water supply purposes until such time as it is needed for navigation purposes". Subsequently, recreation under the 711 program and use of the navigation storage for water supply purposes until such time as it is needed for navigation.

b. Water Use Contracts: Contracts with Benbrook Water and Sewer Authority for 22.7 percent, or approximately 16,458 acre-feet of the storage between elevations 665 and 694 for water supply purposes.

LOCATION: R.M. 15 on Clear Fork of Trinity River, 10 miles southwest of Fort Worth, Tarrant County, TX

DRAINAGE AREA:
429 square miles
One inch of runoff 22,880 acre-feet

DAM:
Type: Rolled earth fill
Length: 9130' (including spillway)
Maximum Height: 130'
Top Width: 20'

SPILLWAY:
Crest Elev: 724.0, w/100' notch in center, crest 710.0
Length: 500' (including 100' notch)
Type: Ungated ogee

OUTLET WORKS:
Type: 1 conduit w/2 gated inlets
Dimensions:
Conduit: 13'
Inlets: 2-6.5'x13'
Control: 2-6.5'x13' broome-type gates
Invert Elev: 622.0

LOW-FLOW OUTLETS:
Type: 2-30" steel pipes, paralleling flood control conduits
Invert Elev: 656.0 (at intake to wet well)
Release Versatility: Controllable down to approx. 5-10 cfs

POWER FEATURES:
None

Feature	Elev Feet (msl)	Reservoir Area (acres)	Reservoir Capacity: Accumulative (ac-ft)	Reservoir Capacity: Runoff (inches)	Reservoir Capacity: Incremental (ac-ft)	Spillway & Notch Capacity (cfs)	Flood Control Outlets Capacity (cfs): 1 Int	Flood Control Outlets Capacity (cfs): 2 Int	Low Flow Outlets Capacity (cfs): 1 Int	Low Flow Outlets Capacity (cfs): 2 Int
Top of Dam	747.0									
Maximum Design Wtr Surface	741.0	10,300	410,000	17.92		172,000	6,400	8,000		
Emerg Spillway Crest	724.0	7,630	258,600	11.30	170,350	17,000	5,860	7,840		
Notch Crest and Top of Controlled Flood Storage	710.0	5,820	164,800	7.20			5,380	7,310	130	260
Top of Conserv Storage	694.0	3,770	88,250	3.86	72,500		4,770	6,510	120	240
Inverts at Intake Low-Flow Outlets	656.0	730	6,550	0.29						
Invert at Lowest Intake	622.0	7	12							
Streambed	617.0									
Sediment Reserve					15,750					
Total Storage					258,600					

(IN OPERATION)

(May 1977) BENBROOK LAKE

Exhibit 1

00392

Contract with City of Fort Worth for 10 percent, or approximately 7,250 acre-feet of the storage between elevations 665 and 694 for water supply purposes and for an additional 775 acre-feet of water per annum for the purpose of satisfying downstream riparian and/or appropriative rights. All current water use contracts specify that use of storage for water supply purposes will cease when the storage is needed for navigation. The City of Fort Worth has recently requested the Corps of Engineers to prepare a draft contract for interim use of the remaining navigation storage for water supply purposes.

c. Interagency Agreements: None

d. Informal Commitments: If conditions permit, water is released at rate of approximately 140 c.f.s. during one weekend each spring for a "float-in" along the Clear Fork. This event is sponsored by the Greater Fort Worth Group of the Sierra Club and by Explorer Post 425 of the Boy Scouts of America and attracts thousands of canoeists, rafters and innertubers. Also, if conditions permit, release of water from the lower portion of the flood control storage is discontinued during the Mayfest to prevent disruption of boating activities in the Clear Fork. The Mayfest is a 5-day festival in early May sponsored by the Fort Worth Junior Womans League.

e. Systems Regulation Objectives: Benbrook Lake is a unit of the comprehensive program for the development of water resources of the Trinity River Basin. Other existing units of this program include five multiple-purpose lakes and several floodway and channel improvement projects constructed by the Corps of Engineers. Benbrook Lake is to be regulated to control flooding along the Clear and West Forks of the Trinity River and, in combination with Lewisville, Grapevine, Lavon, Bardwell and/or Navarro Mills Lakes, to control flooding along the Trinity River. Releases from the navigation storage are to be made in accordance with the water supply contracts, the water use permits granted by the State of Texas, and the plan for low flow releases approved by the State of Texas.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects: The impoundment greatly increases the quantity of water available for beneficial uses such as water supply, navigation, lake fishing and lake recreation. The impoundment serves as an effective sediment trap and the turbidity of inflowing flood

water is decreased markedly in a fairly short period of time. Available data indicates that the quality of the impounded water is generally good and that the impoundment tends to reduce the frequently high fecal coliform counts of the inflow water to acceptable levels.

(2) Negative effects: Thermal stratification of impounded water can be expected from April through the middle of October with the thermocline located at 20 to 30 feet below the surface. During the period of thermal stratification, dissolved oxygen concentration in the hypolimnion is usually less than 3 mg/l and decreases to zero or near zero at the bottom of the impoundment. Water released from the hypolimnion during the summer months often has a hydrogen sulfide odor. The concentration of dissolved iron and manganese can be expected to increase substantially in the hypolimnion while the impoundment is thermally stratified.

(3) Cause of negative effects: The negative effects of the impoundment on the stored water are attributed to the thermal stratification and the natural chemical composition of the inflow water. Use of project lands and land use over the remainder of the project watershed are believed to have only a minimal effect on the quality of the stored water.

b. Project Effects on Instream Flows:

(1) General: Monthly discharge-frequency and flow duration curves for pre- and post-impoundment conditions at a point immediately downstream from the impoundment are presented on Plates 1 through 24. Note that the period-of-record for the two conditions are not the same. The curves on Plates 1 through 24 do not indicate the large number of days per year (a mean of about 95 days) that there was zero flow in the Clear Fork under pre-impoundment conditions.

(2) Positive effects: The impoundment has prevented or reduced damaging flooding along the Clear and West Forks of the Trinity River and the Trinity River, resulting in a substantial reduction in flood damages which would have occurred without the project. The monthly discharge-frequency curves shown on Plates 1 through 12 do not adequately describe the amount of reduction in flooding because flood hydrographs in the lower reaches of the Clear Fork are characteristically sharp-crested and of short duration; e.g., duration of the maximum flood of record in May 1949 was only about 1 day. Small amounts of leakage through the gates controlling the impoundment has resulted in some improvement in the extreme low flow conditions in the Clear Fork. The gate leakage has decreased the mean number of days per year with

zero flow when compared to pre-impoundment conditions and has supplanted the zero flow with flow of near zero to about 3 c.f.s. The quality of water released can be expected to be good when the impoundment is not thermally stratified.

(3) Negative effects: With the exception of the improvement in extreme low flow conditions described in paragraph 5b(2), the impoundment has caused a reduction in the downstream low flow. This reduction has adversely affected the instream flow needs for fishery maintenance, especially in the reach between the impoundment and the head of the Clear Fork Extension of the Fort Worth Floodway project. The Fort Worth District, Corps of Engineers has recently estimated the monthly instream fishery maintenance flow needs along this reach of the Clear Fork based upon a composite of pre-impoundment average and pre-impoundment median low flows as determined using the Montana Method and the Modified Tennant's Method, respectively. These flows are:

Month	Flow (c.f.s.)	Month	Flow (c.f.s.)
JAN	5	JUL	3
FEB	15	AUG	3
MAR	20	SEP	3
APR	20	OCT	3
MAY	20	NOV	3
JUN	10	DEC	3

Water released when the impoundment is thermally stratified can be expected to exhibit a low dissolved oxygen concentration, a hydrogen sulfide odor and increased levels of dissolved iron and manganese.

(4) Cause of negative effects: Any degradation in the quality of water released from the impoundment can be attributed to thermal stratification of the impoundment and the fact that all releases must be made from the poorer-quality water in the hypolimnion. Degradation in the quantity of water released to approximately match pre-impoundment low flow conditions can be attributed to inadequate provisions in the water use permits granted by the State of Texas, in the water use contracts described in paragraph 4b, and in the plan for low flow releases approved by the State of Texas.

c. Project Effects on System Regulation: Benbrook Lake has been operated in conformance with the system regulation objectives specified in paragraph 4e.

6. Constraints on Obtaining Instream Quantity and Quality Objectives:

a. Quantity: The smallest practicable release from the impoundment is 5 to 10 c.f.s. Small incremental increases in release rates would be difficult to achieve. The State of Texas has not required water to be released from the impoundment for fish and wildlife purposes. There are no provisions in existing water supply contracts or water use permits for releases to satisfy downstream fishery needs described in paragraph 5b(3).

b. Quality: There is no multiple-level selective withdrawal system for the outlet works or the low-flow outlets of Benbrook Dam; therefore, all releases must be drawn from the poorer-quality hypolimnion water when the impoundment is thermally stratified.

7. Alternatives:

a. Reservoir Regulation: Studies are in progress which may result in changes in the plan for low flow releases from the 48,015 acre-feet of navigation storage which has not been contracted for water supply purposes. Changes, if any, would be designed to at least partially satisfy the downstream fishery needs.

b. Structural Modifications: Studies are in progress which may result in structural modifications designed to eliminate or reduce the constraints on obtaining the exact rates and quality of water needed to meet downstream fishery needs. Structural modifications to be considered include a multiple-level selective withdrawal system for the low-flow outlets and a small downstream structure for control of small low flow releases. Studies have not progressed far enough to allow accurate cost estimates for these modifications.

c. Storage Reallocation: No reallocation of storage is being considered at this time.

d. Other: Aeration of the hypolimnion water will be considered during studies to improve the low flow releases. Cost of the aeration system has not been developed.

8. Actions Taken to Date: Benbrook Lake is one of eight Fort Worth District Projects identified as not having satisfactory low flow releases and is the first of the eight projects being studied for possible improvement in the low flow conditions downstream from the

project. To date, the Benbrook Lake studies have focused on coordination with the U.S. Fish and Wildlife Service regarding downstream fishery needs; development of low flow release rates needed to maintain a fishery in the Clear Fork; an analysis of existing legislation, water supply contracts, water use permits, cost allocations and regulation plans pertaining to the use of the conservation storage of Benbrook Lake; and a determination of the effects of various fishery maintenance release plans on the impoundment levels and on the characteristics of the downstream flows.

9. Planned Actions: Studies of Benbrook Lake for possible improvement in downstream low flow conditions are continuing. In view of the recent request of the City of Fort Worth to contract for the unobligated navigation storage of the impoundment, it has been recommended that any such contractual agreement be responsive to identified instream flow needs, in which case an environmental impact assessment would probably suffice to meet NEPA requirements. Further, it has been recommended that an environmental impact statement may be needed to resolve controversial issues which may arise if the combined water supply contract and revised plan for low flow releases fail to be responsive to instream flow needs downstream from Benbrook Lake. A rough estimate of the cost to complete the studies, including additional hydrologic analyses, environmental analyses, coordination with other agencies, contract negotiations, etc. is $45,000. Schedule for completion of the studies will be dependent on manpower and funds availability. Objectives have been stated previously in this report.

LEWISVILLE LAKE, TEXAS

1. Project Name: Lewisville Lake

2. Project Location: River mile 30.0 on Elm Fork of the Trinity River. The project watershed (1,660 square miles) is located in the State of Texas and the downstream water management control stations are located in Texas.

3. Type of Project:

a. General Category: Multiple-purpose storage lake (excluding hydropower).

b. Storage Allocations and Other Pertinent Data: See Exhibit 1. The total storage below the top of conservation pool, elevation 515.0 feet, n.g.v.d., is approximately 464,500 acre-feet. Of this approximately 28,500 acre-feet is allocated for sediment accumulation and approximately 436,000 acre-feet is allocated for water supply. See paragraph 4b for water supply contracts.

4. Water Management Criteria:

a. Authorized Project Purposes: Flood control, water supply, and recreation by 711 program.

b. Water Use Contracts: The City of Dallas has contracted for 310,000 acre-feet of the available water supply storage and in addition received 105,000 acre-feet of water supply storage in exchange for its rights and privileges in the old Lake Dallas. The City of Denton has contracted for 21,000 acre-feet of the available water supply storage below elevation 515.0 feet, n.g.v.d.

c. Interagency Agreements: None

d. Informal Commitments: The Texas Game and Fish Commission by agreement secures water for the State Fish Hatchery below Lewisville Dam through two 12-inch water lines which are connected, one each, to the 60-inch low-flow conduits.

e. Systems Regulation Objectives: The Lewisville Dam project is designed to provide flood protection to the lands along the Elm Fork between the dam and the mouth of Denton Creek; to provide, in conjunction with the Grapevine project, a measure of flood protection to the lands along the Elm Fork between the mouth of Denton

LOCATION: R.M. 30.0 on Elm Fork of the Trinity River near Lewisville, Denton County, and about 22 miles northwest of Dallas, Texas

DRAINAGE AREA:
1,660 square miles
One inch of runoff - 88,533 acre-feet

DAM:
Type: Rolled earth fill
Length: 32,888 feet (including spillway)
Maximum Height: 125 feet
Top Width: 20 feet

SPILLWAY:
Crest Elevation: 532.0 feet
Length: 560 feet
Type: Ungated ogee

OUTLET WORKS:
Type: 1 conduit with 3 gated inlets
Dimensions:
Conduit: 16 feet
Inlets: 3-6.5'x13'
Invert Elevation: 448.0 feet
Control: 3-6.5'x13' broome-type gates

LOW-FLOW OUTLETS:
Type: 2-60" steel pipes, 1 on each side of F.C. conduit
Invert Elev at Intakes: 2 at 481.0, 1 at 496.0, and 1 at 503.0
Control: 2-48" valves at downstream end of 60" pipe 1/
Release Versatility: Control down to approx. 5-10 c.f.s.

1/Being modified from 2-36" values (Jan 66)

Feature	Elev Feet (msl)	Reservoir Area (acres)	Reservoir Capacity: Accumulative (ac-ft)	Reservoir Capacity: Runoff (inches)	Reservoir Capacity: Incremental (ac-ft)	Spillway Capacity (cfs)	Flood Control Outlets Capacity (cfs): 1 Int	2 Int	3 Int	Low-Flow Outlets Capacity (cfs): 1 pipe	2 pipes
Top of dam	560.0										
Maximum design water surface	553.0	66,100	2,082,800	23.53		216,800	5,760	11,130	12,600		
Top of flood control pool and spillway crest	532.0	39,080	989,700	11.18	525,200	0	5,050	9,750	11,050		
Top of conservation pool	515.0	23,280	464,500	5.25	436,000		4,400	8,490	9,620	360	720
Invert 1 low-flow intake	503.0	13,920	246,600	2.78			3,860	7,470	8,470	320	650
Invert 1 low-flow intake	496.0	10,680	159,200	1.80			3,510	6,800	7,730	300	600
Invert 2 low-flow intakes	481.0	4,750	44,080	0.50			2,620	5,100	5,780	0	0
Invert at lowest intake	448.0	12	30	0.00			0	0	0	0	0
Streambed	435.0*										
Sediment Reserve					28,500						
Total Storage					989,700						

* Original: 1960 resurvey - 444.0

(IN OPERATION)

LEWISVILLE LAKE

(May 1977)

Creek and the City of Dallas and a high degree of protection to the leveed areas of the City of Dallas from floods originating on the Elm Fork; in conjunction with the Benbrook, Grapevine, Lavon, and existing non-Federal reservoir projects on the West Fork, to provide a reasonable degree of supplementary flood protection to the rural areas in the flood plain between the reservoirs and the mouth of Richland Creek; and to provide a dependable supply of water for municipal uses.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: The impoundment of water behind Lewisville Dam tends to reduce the turbidity associated with storm runoff waters. The dam acts as a sediment retarding structure and reduces the downstream sediment loading. Available data indicates that the quality of the impounded water is generally good.

(b) Quantity: The project has greatly increased the quantity of water available for beneficial purposes such as water supply, lake recreation, and lake fishing.

(2) Negative effects: Thermal stratification of the impounded waters begins to develop in early to late April and persists until September or October. The thermal stratification results in noticeable seasonal and areal variations in dissolved oxygen and dissolved iron and manganese. During the summer months the dissolved oxygen concentration in the hypolimnion tends to approach zero near the bottom of the lake. During this period that portion of the lake with sufficient dissolved oxygen to sustain fish life is restricted to the top 35 to 40 feet of depth. With a decrease in dissolved oxygen to zero the concentrations of dissolved iron and managanese tends to increase. The beach areas may also have an increase, in fecal coliform counts during the summer heavy use periods. There may also be periodic increases in algal growth as nutrient loadings increase either from the tributary inflows, septic tank seepage within the watershed, or the sewage effluent entering the lake from wastewater treatment plants from cities near the lake.

(3) Cause of negative effects: The thermal stratification pattern of the impounded waters and the quality of the inflow and

runoff waters are the main cause of the variance in the quality of the water in Lewisville Lake.

b. Project Effects on Instream Flows:

(1) General: Monthly flow volume frequency and duration curves for the project under pre- and post-impoundment conditions are shown on Plates 1 through 24. It should be noted that the periods of record for the two conditions are not the same.

(2) Positive effects: The Lewisville Dam project generally tends to smooth the sharp crested flood flows generated by the watershed area above the dam. The presence of the dam prevents some downstream flood damages that would have occurred without the project having been constructed. The plan of regulation for the low-flow releases has improved the downstream flows during the summer by reducing the number of days of zero flow. The quality of the release waters is unknown as the water has not been monitored and thus the effect of the releases on downstream conditions is unknown. The low-flow releases are usually made through the upper most available port thus releasing the best possible quality of water and yielding the least detrimental effect on the downstream area.

(3) Negative effects: Low-flow releases are made upon request of the City of Dallas and may thus cause fluctuation in the downstream stages.

(4) Cause of negative effects: Any degradation in the quality of the water downstream or the project is probably attributable to the City of Lewisville wastewater effluent outfall located just downstream of the stilling basin. The presence of the project and the subsequent thermal stratification of the impounded water may also have some detrimental effect but the extent is unknown.

c. Project Effects on System Regulation: Lewisville Dam is a unit in a comprehensive plan for controlling floods on the Upper Trinity River Basin. Releases from Lewisville Dam must be coordinated with outflows from Benbrook, Grapevine, and Lavon and existing non-Federal reservoir projects. Improper regulation of Lewisville Dam has the potential of causing flooding and of causing downstream fish kills.

6. Constraints on Obtaining Instream Quality and Quantity Objectives: Unless the project is improperly operated, below project instream flow maintenance needs should be satisfied.

7. Alternatives:

a. Reservoir Regulation: None proposed.

b. Structural Modification: None proposed.

c. Storage Reallocation: None proposed.

8. Actions Taken to Date: The Fort Worth District has conducted three meetings with the U.S. Fish and Wildlife Service in connection with flow maintenance downstream of the Fort Worth District projects. Inasmuch as the U.S. Fish and Wildlife Service agrees with the Fort Worth District assessment that releases from Grapevine Dam are satisfactory, no additional study or actions for flow maintenance are planned.

9. Planned Actions: None proposed.

GRAPEVINE LAKE, TEXAS

1. Project Name: Grapevine Lake

2. Project Location: River mile 11.7 on Denton Creek, Trinity River Basin. The project watershed (695 square miles) is located in the State of Texas and the downstream water management control stations are located in Texas.

3. Type of Project:

a. General Category: Multiple-purpose storage lake (excluding hydropower).

b. Storage Allocations and Other Pertinent Data: See Exhibit 1. Of the storage below top of conservation pool, elevation 535.0 feet n.g.v.d., approximately 161,250 acre-feet is contracted for water supply and approximately 25,000 acre-feet is allocated for navigation. See paragraph 4b for water supply contracts.

c. Hydropower Category: N/A

4. Water Management Criteria:

a. Authorized Project Purposes: Flood control, water supply, navigation, and recreation by 711 program.

b. Water Use Contracts: The City of Grapevine has contracted for 1,250 acre-feet of conservation storage and is negotiating for all of the 25,000 acre-feet of navigation storage for water supply until such time as it is needed for navigation purposes. The Dallas County Park Cities has contracted for 50,000 acre-feet of the available water supply storage. The remaining 85,000 acre-feet of available water supply storage has been contracted for by the City of Dallas.

c. Interagency Agreements: None.

d. Informal Commitments: Reservoir regulation plan calls for 10 c.f.s. to be released during the months May through August and 5 c.f.s. during the months September through April for stream regulation

LOCATION: In Tarrant and Denton Counties, R.M. 11.7 on Denton Creek, Trinity River Basin near Grapevine and about 20 miles northwest of Dallas, TX

DRAINAGE AREA:
695 square miles
One inch of runoff 37,067 acre-feet

DAM:
Type: Rolled earth fill
Length: 12,850' (including spillway)
Maximum Height: 137'
Top Width: 28'

SPILLWAY:
Crest Elev: 560.0
Length: 500'
Type: Upgated ogee

OUTLET WORKS:
Type: 1 conduit w/2 gated inlets
Dimensions:
Conduit: 13'
Inlets: 2-6.5' x 13'
Invert: 475.0
Control: 2-6.5' x 13' broome-type gates

LOW FLOW OUTLETS:
Type: 2-30" steel pipes, paralleling flood control conduit, 3' x 5' intake ports.
Invert: 2 at 500.5, 1 at 512.5, and 1 at 520.0
Release versatility: Control down to approximately 5-10 c.f.s.

NOTE: Area-capacity data based on 1966 sedimentation resurvey of Grapevine Lake.

Feature	Elev Feet (msl)	Reservoir Area (acres)	Reservoir Capacity: Accumulative (ac-ft)	Reservoir Capacity: Runoff (inches)	Reservoir Capacity: Incremental (ac-ft)	Spillway Capacity (cfs)	Flood-Control Outlet Capacity (cfs): 1 Int	Flood-Control Outlet Capacity (cfs): 2 Int	Low-flow Outlet Capacity (cfs): 1 Int	Low-flow Outlet Capacity (cfs): 2 Int
Top of Dam	588.0									
Maximum Design Water Surface	581.0	19,420	758,800	20.47		182,500	6,000	8,200		
Top of Flood-Control Pool & Spillway Crest	560.0	12,710	425,500	11.48	243,050	0	5,270	7,240	150	300
Top of Conservation Pool	535.0	7,280	181,100	4.89	154,250		4,260	5,890	126	252
Inverts at Intake, Low-Flow Outlets	500.5	2,140	22,145	0.60			2,600	3,720	0	0
Invert at Lowest Intake	475.0	41	98	0			0	0		
Streambed	451.0									
Sediment Reserve					28,200*					
Total Storage					425,500					

* Sediment distributed as follows: 26,850 ac-ft below elev 535,0
1,350 ac-ft between elev 535.0 and 560.0

(IN OPERATION)

(May 1977) GRAPEVINE LA

Exhibit 1 00404

e. System Regulation Objectives: Grapevine Reservoir is a unit in a comprehensive plan for controlling floods on the Upper Trinity River Basin. Releases from Grapevine Reservoir will be coordinated with outflow from Benbrook Reservoir on the Clear Fork and from Garza-Little Elm Reservoir on the Elm Fork. Releases will also be coordinated, insofar as possible, with discharges from the locally or privately owned reservoirs on the West Fork above Fort Worth and on Mountain Creek near Dallas. Current stage and discharge records on Denton Creek near Grapevine, on the Elm Fork at Carrollton, on the West Fork at Grand Prairie, and on the Trinity River at Dallas; as well as the available storages, inflows, and releases of the privately owned reservoirs, will be used as aids for the proper regulation of Grapevine Reservoir.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: Available data indicates that the quality of the impounded water is generally good. The pH of the impounded water tends to be on the high side of the recommended Texas Water Quality Standards. The impoundment of the Denton Creek waters behind Grapevine Dam tends to reduce turbidity associated with storm runoff waters. The dam likewise tends to act as a sediment retarding structure reducing the downstream sediment load.

(b) Quantity: The impoundment tends to smooth out the flows of the damsite by reducing the sharp crested flash type floods of the Denton Creek watershed. The project has greatly increased the quantity of water available for beneficial uses such as water supply, navigation, lake recreation, and lake fishing.

(2) Negative effects: Thermal stratification of the lake waters begins to develop in early to late April and continues until September or October. The thermal stratification results in seasonal and areal variations in the quality of the lake waters. Oxygen utilized in the oxidation of dead organisms and other organic materials near the bottom of the lake especially during the summer months leads to a near anaerobic environment. Consequently, water below a 35 to 40 foot depth usually has less than the 4.0 mg/l of dissolved oxygen required for sustaining fish life. During the summer months the concentrations of such constituents as dissolved iron and manganese can be expected to increase in the lower levels of the lake.

(3) Causes of negative effects: The thermal stratification pattern of the impounded waters is the main cause of the variance in the quality of the water in Grapevine Lake. The inflow waters and the use of septic tanks along the tributaries may also cause short term variances in the headwaters of the lake. Since the conservation storage releases are made upon request daily fluctuations in the tailwater may occasionally be experienced.

b. Project Effects on Instream Flows:

(1) General: The monthly flow volume frequency and duration curves for flows immediately downstream of the project under pre- and post-impoundment conditions are shown on Plates 1 through 24. It should be noted that the periods of record for the two conditions differ.

(2) Positive effects: Grapevine Dam tends to smooth the sharp crested flash type flood flows generated by the Denton Creek watershed above the damsite. The presence of the dam prevents downstream flood damages that would have occurred without the dam having been constructed. The regulation schedule for low-flow releases has improved the downstream flows during the summer by decreasing the number of days of zero flow. This improvement in downstream low-flows improves the downstream fish habitat and helps meet the instream flow maintenance flow needs downstream of the project. The limited data available on the quality of the release and downstream waters indicates the quality is generally good. The conservation storage releases are generally made through the upper most low-flow port in order to give the best quality water. Minimum low-flow releases of 10 c.f.s. during May through August and 5 c.f.s. from September through April are made for stream regulation.

(3) Negative effects: Limited analysis of the project release waters indicates that the quality of the releases may occasionally be outside the Texas Water Quality Standards, especially during the summer months. The data indicates that the pH of the samples tested ranged from 7.3 to 8.8 with an average of 8.1, a standard deviation of .35, and 3 out of 44 samples being outside the standard of 6.5 to 8.5 Of 19 samples tested for chlorides, 3 were outside the 80 mg/l standard. The sample concentrations ranged from 25 mg/l to 100 mg/l, averaged 60.8 mg/l, and had a standard deviation of 23.1 mg/l. The sulfate concentrations of the samples tested ranged from 15 mg/l to 74 mg/l with a mean of 36.5 mg/l and only 1 of 28 samples exceeded the 60 mg/l standard. Of the 15 fecal coliform counts taken, 3 exceeded the limits of 200/100 ml. The counts ranged from 0 to 380/100 ml with an average count of 98/100 ml and a standard deviation of 118/100 ml.

(4) Cause of negative effects: Any degradation in the quality of the water directly below Grapevine Dam can be attributed to the presence of the project, the subsequent thermal stratification of the impounded waters, the operation of the multiple level low-flow ports, and the quality of the inflow and runoff waters.

c. Project Effects on System Regulation: Grapevine Dam is a unit in a comprehensive plan for controlling floods on the Upper Trinity River Basin. Release from Grapevine must be coordinated with outflow from Benbrook Lake on the Clear Fork and from Lewisville Lake on the Elm Fork. Improper regulation of Grapevine Dam has the potential of causing flooding downstream. If releases are made such that the poor quality hypolimnetic waters are released especially during the summer months the aquatic life downstream of the project may experience adverse effects.

6. Constraints on Obtaining Instream Quantity and Quality Objectives: The plan of regulation for Grapevine Dam makes a provision for low-flow releases for downstream regulation. Unless the project is improperly operated the quality and quantity of the downstream flows should meet instream maintenance flow needs.

7. Alternatives:

a. Reservoir Regulation: None proposed.

b. Structural Modification: None proposed.

c. Storage Reallocation: None proposed.

8. Actions Taken to Date: The Fort Worth District has conducted three meetings with the U. S. Fish and Wildlife Service in connection with flow maintenance downstream of the Fort Worth District projects. Inasmuch as the U. S. Fish and Wildlife Service agrees with the Fort Worth District assessment that releases from Grapevine Dam are satisfactory, no additional study or actions for flow maintenance are planned.

9. Planned Actions: None proposed.

LAVON LAKE, TEXAS

1. Project Name: Lavon Lake

2. Project Location: River mile 55.9 on the East Fork of the Trinity River. The project watershed (770 square miles) is located in the State of Texas and the downstream water management control stations are located in Texas.

3. Type of Project:

a. General Category: Multiple-purpose storage lake (excluding hydropower).

b. Storage Allocations and Other Pertinent Data: See Exhibit 1. The total storage below the top of conservation pool, elevation 492.0 feet n.g.v.d., is approximately 456,500 acre-feet. Of this approximately 76,500 is allocated for sediment accumulation and approximately 380,000 acre-feet is allocated for water supply. See paragraph 4b for discussion of contracts for water supply.

c. Hydropower Category: N/A

4. Water Management Criteria:

a. Authorized Project Purposes: Flood control, water supply, and recreation by 711 program.

b. Water Use Contracts: The North Texas Municipal Water District has contracted for approximately 220,000 acre-feet, of the storage available for water supply below the top of conservation pool, elevation 492.0 feet n.g.v.d. and have given assurances that it will contract for the remaining water supply storage.

c. Interagency Agreements: None.

d. Informal Commitments: None.

e. Systems Regulation Objectives: Lavon Lake is operated in conjunction with Benbrook Lake on the Clear Fork of the Trinity River, Grapevine Lake on Denton Creek, Lewisville Lake on the Elm Fork of the Trinity River, Navarro Mills Lake on Richland Creek, and Bardwell Lake on Waxahachie Creek to effect maximum flood control benefits on the East Fork of the Trinity River below the dam and on the Trinity River below the mouth of the East Fork.

LOCATION: In Collin County, R.M. 55.9 on the East Fork of the Trinity River near Wylie and about 22 miles northeast of Dallas, Texas

DRAINAGE AREA:
770 square miles
One inch of runoff 41,067 ac-ft

DAM:
Type: Earth fill
Length: 19,493' (including spillway)
Maximum Height: 81'
Top Width: 30'

SPILLWAY:
Crest Elev: 475.5
Length: 480' net at crest
Type: Ogee
Control: 12 - 40'x28' tainter gates

INFLOW:
Spillway design flood peak, cfs 460,000
Spillway design flood volume, ac-ft 1,070,500
Spillway design flood runoff, inches 25.68

OUTFLOW:
Total routed peak outflow, cfs 359,000

OUTLET WORKS:
Type: Five gate controlled sluices through spillway piers
Dimensions: 36" diameter
Invert Elev: 1 @ 482.0, 1 @ 472.0, 3 @ 453.0
Control: 5 - 36" manually operated slide gates
Release versatility: Controllable down to approximately 2 c.f.s.

WATER SUPPLY
Contractor: North Texas Municipal Water District
Type Release: Pumped

Feature	Elev Feet (msl)	Reservoir Area (acres)	Reservoir Capacity: Accumulative (ac-ft)	Reservoir Capacity: Runoff (inches)	Reservoir Capacity: Incremental (ac-ft)	Spillway Capacity (cfs)	Outlet Works Capacity (cfs)
Top of Dam	514.0						
Maximum Design Water Surface	509.0	33,500	921,200	22.23		357,700	
Top of Flood Control Pool (Top of Gates)	503.5	29,450	748,200	13.06	275,600		1,200
Top of Conservation Pool	492.0	21,400	456,500	11.02	380,000		1,000
Spillway Crest	475.5	12,750	178,300	4.30			
Invert at Lowest Intake	453.0	2,870	12,700	0.31			
Maximum Tailwater	471.0						
Sediment Reserve					92,600		
Total Storage					748,200		
Steambed	433.0						

(IN OPERATION)

LAVON LAKE

(May 1977)

Exhibit 1

00409

5. <u>Project Evaluation</u>:

a. <u>Effects of Impoundment on Water Stored</u>:

(1) Positive effects:

(a) Quality: Available data indicates that the quality of the impounded water is generally good. Occasional sample constituents may, however, be found to exceed recommended Texas Water Quality Standards. The project in general acts as a sediment retarding structure and reduces turbidity associated with storm runoff.

(b) Quantity: The project tends to reduce and smooth the peak flood flows generated by the watershed above the lake. The project provides storage for flood waters and for municipal and industrial use. The project has greatly increased the quantity of water available for beneficial uses such as water supply, lake recreation, and lake fishing.

(2) Negative effects:

(a) Quality: Thermal stratification of the impounded waters begins to develop in early to late April and persists until September or October. The thermal stratification results in seasonal and areal variations in dissolved oxygen. During the summer months the dissolved oxygen is depleted and tends to approach zero at the bottom. During this period only the top 30 to 35 feet of depth is capable of sustaining fish life. The Pilot Grove Arm of the lake has been found to have higher than usual levels of arsenic and the lake experienced algal blooms in several areas. During the period of greatest stratification taste problems have been reported and dissolved metals concentrations can be expected to increase as the hypolimnion becomes anaerobic.

(b) Quantity: The conservation storage releases are made either through the North Texas Municipal Water District outlet facilities or downstream upon request. This may cause fluctuation in the tail-water. The project has inundated lands formerly used for agriculture or grazing and for wildlife habitat.

(3) Cause of negative effects: The impoundment of the water behind Lavon Dam and the subsequent thermal stratification pattern

are the main causes of the depletion of dissolved oxygen, the increase in dissolved metals, and the creation of an environment conducive to algal blooms and taste problems. The use of septic tanks along the upstream tributaries and around the lake may contribute nutrients that are conducive to algal growth. The high arsenic concentrations are probably due to the City of McKinney sewage treatment plant upstream of the reservoir.

b. Project Effect on Instream Flows:

(1) General: A comparison of the monthly flow volume frequency and duration curves for the Lavon Lake project under pre- and post-impoundment conditions are shown on Plates 1 through 24. It should be noted that the periods of record for the two conditions are not the same.

(2) Positive effects: The Lavon Dam project generally tends to decrease the peak flood flows passing the damsite and smooths the flood flows generated by the upstream watershed. The project reduces downstream damages. The quality of the release waters and its effect on the downstream environment is not known. The fishing below the project is good.

(3) Negative effects:

(a) Quality: During the summer months hydrogen sulfide odors have occasionally been evidenced with the low-flow releases and algae has been evidenced in the stilling basin. Since the quality of the downstream and the release waters is not monitored the impact of the Lavon Dam releases on the downstream is unknown.

(b) Quantity: A preliminary best-estimate by the Corps of Engineers of instream flow needs on a monthly basis for Lavon Dam was computed based on pre-impoundment and post-impoundment periods of record flows. Since the two periods of record differ, they should be analyzed to determine natural climatic variations and the preliminary estimates adjusted appropriately. The following represents a composite instream maintenance flow based on pre-impoundment average and pre-impoundment median low-flow as determined through the Montana Method and the Modified Tennant's Method respectively.

Month	Flow, c.f.s.	Month	Flow, c.f.s.
JAN	60	JUL	30
FEB	70	AUG	5
MAR	100	SEP	5
APR	100	OCT	10
MAY	100	NOV	20
JUN	100	DEC	50

Since impoundment of Lavon Lake the number of days of zero flow passing the damsite has increased, especially during the summer months. This deterioration in low-flow is detrimental to the instream maintenance flow needs downstream of the project.

(4) Cause of negative effects: Any degradation in the quality of the water directly below Lavon Dam can be attributed in part to the construction of the dam, the subsequent thermal stratification of the impounded water, and to the quality of the inflow waters. Since the conservation storage releases to the downstream channel are made only upon request by the using agency the increase in the number of days of zero flow passing the damsite is under the control of the North Texas Municipal Water District.

c. Project Effects on System Regulation: Lavon Dam and Lake project is an integral part of the plan for controlling floods in the Trinity River Basin and for providing municipal and industrial water supplies. Coordinated releases from the projects in the system must be made to provide good quality flows and maximum flood control benefits.

6. Constraints on Obtaining Instream Quantity and Quality Objectives: The State of Texas claims the rights to the water within its boundaries and requires a using agency to obtain a permit to use the water. Historically, the State of Texas has not required the North Texas Municipal Water District to make a guaranteed minimum release from Lavon Dam. Since downstream releases are made only upon request and the majority of the conservation storage water is taken from the lake by pipeline the number of days of zero flow has increased.

7. Alternatives:

a. Reservoir Regulation: The Fort Worth District has conducted three meetings with the U. S. Fish and Wildlife Service in connection

with flow maintenance downstream of the Fort Worth District projects. Lavon Lake is one of the projects requiring further detailed study. The study will investigate the feasibility of changing the existing plan of operation for possible improvement in low flows.

b. Structural Modification: None proposed.

c. Storage Reallocation: The detailed study will investigate the possibility of reallocating storage for possible improvement in low-flow releases by reducing the number of zero flow days. Any reallocation of storage would have to be specifically authorized by amendment by the Congress.

8. Actions Taken to Date: See paragraph 7.

9. Planned Actions: A detailed study of the project will be conducted with emphasis on flow maintenance downstream of the project. The project is one of eight projects for which detailed studies were agreed upon. The eight projects will be studied in downstream order with Lavon Lake being the third project studied. The hydrologic and biologic analyses will be performed and operational and structural alternatives investigated for possible improvement in low flow releases. The increase in the number of days of zero flow passing into the downstream channel is the major area of concern with regards to satisfying instream flow maintenance needs. Preliminary study indicates that either a change in the regulation plan or a storage reallocation is the most feasible approach to satisfying downstream needs. The constraints discussed in paragraph 6 will be considered in the final study. The alternatives evaluated will necessarily take such factors as legal feasibility, downstream and lake fishery, water quality, aesthetics, flood control, water supply, recreation, and periodic shutdowns for maintenance into account. A rough estimate of the cost to complete the studies, including additional hydrologic analyses, environmental analyses, coordination with other agencies, contract negotiations, etc. is $60,000. Schedule for completion of the studies will be dependent on manpower and funds availability.

NAVARRO MILLS, TEXAS

1. Project Name: Navarro Mills

2. Project Location: River mile 63.9 on Richland Creek, Trinity River Basin. The project watershed (320 square miles) is located in the State of Texas and the downstream water management control stations are located in Texas.

3. Type of Project:

a. General Category: Multi-purpose storage lake (excluding hydropower).

b. Storage Allocations and Other Pertinent Data: See Exhibit 1. The total storage below the top of conservation pool, elevation 424.5 feet n.g.v.d., is approximately 63,300 acre-feet. Of this approximately 10,100 acre-feet is allocated for sediment accumulation and approximately 53,200 acre-feet is allocated for water supply. See paragraph 4b for discussion of contracts for water supply.

c. Hydropower Category: N/A

4. Water Management Criteria:

a. Authorized Project Purposes: Flood control, water supply, and recreation by 711 program.

b. Water Use Contracts: The Trinity River Authority has contracted for approximately 53,200 acre-feet, or 100 percent, of the storage available for water supply.

c. Interagency Agreements: None

d. Informal Commitments: None

e. Systems Regulation Objectives: Navarro Mills Dam provides flood protection for that portion of Richland Creek below the dam. In conjunction with Benbrook, Grapevine, Lewisville, Lavon, and Bardwell Dams it is operated as a system for the control of and beneficial use of the surface water resources of the Trinity River Basin.

LOCATION: In Navarro County, R.M. 63.9 on Richland Creek, Trinity River Basin, 16 miles southwest of Corsicana, Texas.

DRAINAGE AREA:
320 square miles
One inch of runoff - 17,067 acre-feet

DAM:

Type:	Earth fill
Length:	7,570' (including spillway)
Maximum Height:	81.7'
Top Width:	20'

SPILLWAY:

Crest Elev:	414.0
Length:	240' net at crest
Type:	Ogee
Control:	6-40'x29' tainter gates

INFLOW:

Spillway design flood peak, cfs	280,500
Spillway design flood volume, ac-ft	521,100
Spillway design flood runoff, inches	30.92

OUTFLOW (Elev 451.9):

Total routed peak outflow, cfs	224,600
Spillway	224,000
Low-flow outlets	600

OUTLET WORKS:
Type (low-flow): 2 conduits
Dimension: 36" diameter
Invert Elev: 400.0
Control: 2-36" manually operated slide gates
Release Versatility: Control down to approx. 5-10 c.f.s.

Feature	Elev Feet (msl)	Reservoir Area (acres)	Reservoir Capacity: Accumulative (ac-ft)	Reservoir Capacity: Runoff (inches)	Reservoir Capacity: Incremental (ac-ft)	Spillway Capacity (cfs)	Outlet Works (Low Flow) Capacity (cfs)
Top of dam	457.0						
Maximum design water surface	451.9	15,950	335,800	19.68		224,000	600
Top of flood control pool (or top of gates)	443.0	11,700	212,200	12.43	143,200		540
Top of conservation pool	424.5	5,070	63,300	3.71	53,200		390
Spillway crest	414.0	2,690	22,100	1.29			
Sediment reserve					15,800*		
Total storage					212,200		
Maximum tailwater	414.3						
Streambed	375.3						

* Sediment distributed as follows: 10,100 ac-ft below elev 424.5
5,700 ac-ft between elev 424.5 and 443.0

(IN OPERATION)

(May 1977)

NAVARRO MILLS LAKE

Exhibit 1

00415

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: Available data indicates that the quality of the impounded waters is generally good, however, occasional samples may show chemical constituent concentrations outside the recommended Texas Water Quality Standards. The project, in general, acts as a sediment retarding structure and reduces the turbidity of storm runoff.

(b) Quantity: The project tends to reduce the peak flows and smooth the storm runoff of the watershed above the dam. The project has greatly increased the quantity of water available for beneficial uses such as water supply, lake recreation, and lake fishing.

(2) Negative effects: A mild thermal stratification begins to develop in late April and persists until September. The stratification results in a depletion of dissolved oxygen in the hypolimnion in the middle to late summer with concentrations at the bottom of the lake approaching zero. During the period of greatest stratification only the top 25 to 30 feet of depth are capable of sustaining fish life for any extended period. Available data indicates that the pH is occasionally in excess of recommended standards and that fecal coliform counts may occasionally be high, especially near beach and park areas during heavy use.

(3) Cause of negative effects: The impoundment of water behind Navarro Mills Dam and the subsequent thermal stratification of the water causes the depletion of dissolved oxygen in the hypolimnion water. The quality of the inflow waters and the heavy use of park and beach areas probably contributes to the occasionally high pH and fecal coliform counts.

b. Project Effect on Instream Flows:

(1) General: Monthly flow volume frequency and duration curves for flows immediately downstream of the Navarro Mills Dam under pre- and post-impoundment conditions are shown on Plates 1 through 24. It should be noted that the periods of record for the two conditions are not the same.

(2) Positive effects: The Navarro Mills project generally tends to smooth the flood waters of Richland Creek passing the damsite. The downstream peak flows and flood damages downstream of the project are reduced. The quality of the release waters and its impact on the quality of the downstream waters is not known as the quality is not monitored.

(3) Negative effects:

(a) Quality: The effects of the project on the downstream quality of water is not known as the quality is not monitored. It is however expected that during the periods of greatest thermal stratification that the waters released from the project will be of a degraded quality. The extent of the degradation is not known but it is expected that the dissolved oxygen concentration will be depressed and the concentrations of dissolved metals will be slightly increased.

(b) Quantity: A preliminary best-estimate by the Corps of Engineers of instream flow needs on a monthly basis for Navarro Mills Dam was computed using pre- and post-impoundment period of record flows. Since the two periods of record differ they should be analyzed to determine natural climatic variations and the preliminary estimates adjusted appropriately. The following represents a composite instream maintenance flow based on pre-impoundment average and pre-impoundment median low flows as determined through the Montana Method and the *Modified Tennant's Method* respectively.

Month	Flow, c.f.s.	Month	Flow, c.f.s.
JAN	20	JUL	10
FEB	20	AUG	5
MAR	50	SEP	5
APR	50	OCT	5
MAY	50	NOV	5
JUN	50	DEC	10

Since impoundment of Navarro Mills Lake the number of days of zero flow passing the damsite has increased, especially during the summer months. This deterioration of low-flows is detrimental to the instream maintenance flow needs downstream of the project.

(4) Cause of negative effects: Any degradation in the quality of the water directly below Navarro Mills Dam can be attributed to the

presence of the project, the subsequent thermal stratification of the impounded waters, and the lack of a multiple level low-flow withdrawal facility at the project. Since the conservation storage waters can only be released from one level the quality of the releases can not be controlled. The State of Texas claims the rights to the waters within its boundaries and requires a using agency to obtain a permit to use the water. Historically the State of Texas has not required the Trinity River Authority to make a guaranteed minimum release from Bardwell Dam. Since conservation releases are made upon request by Trinity River Authority and no minimum releases are required the number of zero flow days has increased since impoundment. Water used for water supply is pumped from the lake rather than being released to a downstream withdrawal point.

c. Project Effects on System Regulation: Navarro Mills Lake provides both flood control and water supply storage. It gives flood protection to about 41,100 acres of flood plain of the Richland Creek below the dam and assists in reducing flood damages to about 452,000 acres in the Trinity River flood plain below the mouth of Richland Creek. The function of the Benbrook and Grapevine Lakes is for flood control, water conservation, and streamflow regulation in the interest of navigation and other beneficial uses. Lewisville, Lavon, Navarro Mills, and Bardwell Lakes operate as a system for the control and beneficial use of the surface water resources of the Trinity River Basin. Improper coordination and operation can be detrimental to flood control and instream maintenance flow needs.

6. Constraints on Obtaining Instream Quantity and Quality Objectives: The project does not have a multiple level release capability and thus releases will be made from the poorer quality hypolimnion waters. The State of Texas claims the rights to the waters within its boundaries and requires a using agency to obtain a permit to use the water. Historically the State of Texas has not required the Trinity River Authority to make guaranteed minimum releases. This increases the days of zero flow and is a constraint on downstream flow maintenance. The releases from the project can only be controlled down to a minimum release of about 5 to 10 c.f.s. and larger release rates can only be controlled to within plus or minus 5 to 10 c.f.s.

7. Alternatives:

a. Reservoir Regulation: The Fort Worth District has conducted three meetings with the U.S. Fish and Wildlife Service in connection with flow maintenance downstream of the FWD projects. It was agreed

that the Fort Worth District would study Navarro Mills Lake and seven other projects in greater detail. The study will include the feasibility of changing the regulation plan. See paragraph 9.

b. Structural Modification: See paragraph 9.

c. Storage Reallocation: See paragraph 9. A change in the storage allocations would have to be specifically authorized by amendment by the Congress.

8. Actions Taken to Date: The Fort Worth District has conducted three meetings with the U.S. Fish and Wildlife Service in connection with flow maintenance downstream of the FWD projects. A detailed study on Navarro Mills Lake and Dam has been agreed upon and the study will be coordinated with the USFWS.

9. Planned Actions: A detailed study of the project will be conducted with emphasis on flow maintenance downstream of the project. The project is one of eight projects for which detailed studies were agreed upon. The eight projects will be studied in downstream order with Navarro Mills being the fifth project studied. The hydrologic and biologic analyses will be performed and operational and structural alternatives investigated for possible improvement in low flow releases. The increase in the number of days of zero flow passing into the downstream channel is the major area of concern with regards to satisfying instream flow maintenance needs. Preliminary study indicates that since all of the available water supply storage is contracted for, either a change in the regulation plan or a storage reallocation is the most feasible approach to satisfying downstream needs. The constraints discussed in paragraph 6 will be considered in the final study. The alternatives evaluated will necessarily take such factors as legal feasibility, downstream and lake fishery, water quality, aesthetics, flood control, water supply, recreation, and periodic shutdowns for maintenance into account. A rough estimate of the cost to complete the studies, including additional hydrologic analyses, environmental analyses, coordination with other agencies, contract negotiations, etc. is $55,000. Schedule for completion of the studies will be dependent on manpower and funds availability. Objectives have been stated previously in this report.

BARDWELL LAKE, TEXAS

1. Project Name: *Bardwell Lake*

2. Project Location: River mile 5.0 on Waxahachie Creek, Richland-Chambers watershed, Trinity River Basin. The project watershed (178 square miles) is located in the State of Texas and the downstream water management control stations are located in Texas.

3. Type of Project:

a. General Category: Multi-purpose storage lake (excluding hydropower).

b. Storage Allocations and Other Pertinent Data: See Exhibit 1. The total storage below the top of conservation pool, elevation 421.0 feet n.g.v.d., is approximately 54,900 acre-feet. Of this approximately 12,100 acre-feet is allocated for sediment accumulation and approximately 42,800 acre-feet is allocated for water supply. See paragraph 4b for discussion of contracts for water supply.

c. Hydropower Category: N/A

4. Water Management Criteria:

a. Authorized Project Purposes: Flood control, water supply, and recreation by 711 program.

b. Water Use Constracts: Trinity River Authority has contracted for 42,800 acre-feet, or 100 percent, of the available water supply storage below top of conservation pool, elevation 421.0 feet n.g.v.d.

c. Interagency Agreements: None.

d. Informal Commitments: None.

e. Systems Regulation Objectives: The flood-control releases from Bardwell Lake will be coordinated with releases from the upper Trinity River lakes and the Navarro Mills and Cedar Creek Reservoirs to effect maximum downstream benefits on the Trinity River below the mouth of Richland Creek as well as on Richland Creek.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

LOCATION:
R.M. 5.0 on Waxahachie Creek, Richland-Chambers Creeks Watershed, Trinity River Basin, about 5 miles south of Ennis, Texas

DRAINAGE AREA:
178 square miles
One inch of runoff — 9,493 acre-feet

DAM:

Type:	Earth fill and concrete
Length:	15,400' (including spillway)
Maximum Height:	82'
Top Width:	20'

SPILLWAY:

Crest Elev:	439.0
Length:	350' net at crest
Type:	Broadcrested
Control:	None

INFLOW

Spillway design flood peak, cfs	163,500
Spillway design flood volume, ac-ft	277,700
Spillway design flood runoff, inches	30.10

OUTFLOW:

Total routed peak outflow, cfs	78,000

OUTLET WORKS:
Type: 1 gate controlled conduit
Dimension: 10' diameter
Invert Elev: 391.0
Control: 2-5.0'x10.0' sluice gates
Release Versitility: Controllable down to approximately 5 c.f.s.

Feature	Elev Feet (msl)	Reservoir Area (acres)	Reservoir Capacity: Accumulative (ac-ft)	Reservoir Capacity: Runoff (inches)	Reservoir Capacity: Incremental (ac-ft)	Spillway Capacity (cfs)	Outlet Works Capacity (cfs)
Top of Dam	460.0						
Maximum Design Water Surface	455.9	9,480	268,400	28.27		74,300	3,700
Top of Flood-Control Pool (Spillway Crest)	439.0	6,040	140,000	14.75	79,600	0	3,120
Top of Conservation Pool	421.0	3,570	54,900	5.78	42,800		2,360
Sediment Reserve					17,600		
Total Storage					140,000		
Streambed	377.6						

(IN OPERATION)

(May 1977)

BARDWELL LAKE

Exhibit 1

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(a) Quality: The impoundment tends to play a significant role in reducing the turbidity and suspended sediments associated with storm water runoff. The long-term effect of the impoundment is to act as a detention basin, tending to smooth out sharp variations in chemical quality in the Waxahachie Creek waters. The limited sampling conducted at the lake indicates that the quality of the water is generally good.

(b) Quantity: The impoundment tends to moderate the daily flow volumes passing the damsite by reducing the high flows. Planned operation of the project insures a more uniform streamflow during flood periods than would exist under natural conditions. The project has greatly increased the water available for beneficial uses such as water supply, recreation, and lake fishing.

(2) Negative effects:

(a) Quality: The impoundment experiences a mild thermal stratification during the months of June, July, and August. The hypolimnetic waters of the lake gradually approach an anaerobic condition during these months which tends to cause a slight increase in the dissolved metals concentrations near the bottom of the lake. As the thermal stratification breaks up in the fall these dissolved metals precipitate out and taste and odor problems may occur.

(b) Quantity: The conservation storage releases are made as requested by the Trinity River Authority who has contracted for 25 percent of the conservation storage for present use and 75 percent for future use. Thus the number of zero flow days has increased over natural conditions. The project has inundated lands formerly used as wildlife habitat or other uses.

(3) Cause of negative effects: The impoundment of the Trinity River waters and the thermal stratification pattern of the lake are the main causes of the changes in the quality of the water within the lake. The conservation storage releases are made upon the request of the Trinity River Authority, thus causing an increase in the number of days of zero releases and causing fluctuation in the tailwater.

b. <u>Project Effects on Instream Flows</u>:

(1) General: Monthly flow volume frequency and duration curves for the project under pre- and post-impoundment conditions are shown on Plates 1 through 24. It should be noted that the periods of record are different. The pre-impoundment period is twice as long as the post-impoundment period and contains the record drought period.

(2) Positive effects: In general the quality of the water impounded by Bardwell Dam is good. Of the water samples tested only two were found to have parameter values outside of the Texas Water Quality Standards. The samples indicate that the quality of the impounded and thus the release waters is generally good. The project tends to smooth out the flood flow volumes past the damsite by decreasing the peak flows and passing the flood waters at a lower rate over a longer time, thus reducing downstream flood damages.

(3) Negative effects:

(a) Quality: During the summer months when the lake hypolimnion waters are anaerobic hydrogen sulfide odors are occasionally evidenced with the project releases. The dissolved oxygen concentration during the summer can be expected to be depressed and dissolved metals concentrations can be expected to increase slightly. Since neither the quality of the downstream waters nor the Bardwell Dam releases is monitored the impact on the downstream quality is not known.

(b) Quantity: A preliminary best-estimate by the Corps of Engineers of instream flow needs on a monthly basis for Bardwell Dam was computed using pre- and post-impoundment period of record flows. Since the two periods of record differ they should be analyzed to determine natural climatic variations and the preliminary estimates adjusted appropriately. The following represents a composite increase maintenance flow based on pre-impoundment average and pre-impoundment median low flows as determined through the Montana Method and the Modified Tennant's Method respectively.

Month	Flow, c.f.s.	Month	Flow, c.f.s.
JAN	10	JUL	3
FEB	15	AUG	3
MAR	30	SEP	3
APR	40	OCT	3
MAY	40	NOV	5
JUN	40	DEC	5

Since impoundment of Bardwell Lake the number of days of zero flow passing the damsite has increased, especially during the summer months. This deterioration of low-flows is detrimental to the instream maintenance flow needs downstream of the project.

(4) Cause of negative effects: Any degradation in the quality of the water directly below Bardwell Dam can be attributed to the presence of the project, the subsequent thermal stratification of the impounded waters, and the lack of a multiple level low-flow release facility at the project. Since the conservation storage

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waters can only be released from one level the quality of the releases cannot be controlled. The State of Texas claims the rights to the waters within its boundaries and requires a using agency to obtain a permit to use the water. Historically, the State of Texas has not required the Trinity River Authority to make a guaranteed minimum release from Bardwell Dam. Since conservation releases are made upon request by Trinity River Authority and no minimum releases are required the number of zero flow days has increased since impoundment.

c. Project Effect on System Regulation: The flood-control releases from Bardwell Lake will be coordinated with releases from the Upper Trinity River lakes and the Navarro Mills and Cedar Creek Reservoirs to effect maximum downstream benefits on the Trinity River below the mouth of Richland Creek as well as on Richland Creek. Improper operation of Bardwell Dam may lead to downstream flow and quality deterioration.

6. Constraints on Obtaining Instream Quantity and Quality Objectives: The project does not have a multiple level release capability and thus releases will be made from the poorer quality hypolimnion waters. The State of Texas claims the rights to the waters within its boundaries and requires a using agency to obtain a permit to use the water. Historically, the State of Texas has not required the Trinity River Authority to make guaranteed minimum releases. This increases the days of zero flow and is a constraint on downstream flow maintenance.

7. Alternatives:

a. Reservoir Regulation: The Fort Worth District has conducted three meetings with the U.S. Fish and Wildlife Service in connection with flow maintenance downstream of the Fort Worth District projects. It was agreed that the Fort Worth District would study Bardwell Lake and seven other projects in greater detail. The study will include the feasibility of changing the regulation plan. See paragraph 9.

b. Structural Modification: See paragraph 9.

c. Storage Reallocation: None proposed. A change in the storage allocations would have to be specifically authorized by amendment by the Congress.

d. Other: None proposed.

8. Actions Taken to Date: The Fort Worth District has conducted three meetings with the U.S. Fish and Wildlife Service in connection with flow maintenance downstream of the Fort Worth District projects. A detailed study on Bardwell Lake and Dam has been agreed upon and the study will be coordinated with the U.S. Fish and Wildlife Service.

9. <u>Planned Actions</u>: A detailed study of the project will be conducted with emphasis on flow maintenance downstream of the project. The project is one of eight projects for which detailed studies were agreed upon. The eight projects will be studied in downstream order with Bardwell being the fourth project studied. The hydrologic and biologic analyses will be performed and operational and structural alternatives investigated for possible improvement in low flow releases. Preliminary evaluation of the project indicates that the decrease in low-flow volumes passing the damsite is the area of greatest concern in satisfying downstream need. Thus a change in the plan of regulation or a storage reallocation appears to be the most feasible solution. A rough estimate of the cost to complete the studies, including additional hydrologic analyses, environmental analyses, coordination with other agencies, contract negotiations, etc. is $60,000. Schedule for completion of the studies will be dependent on manpower and funds availability. Objectives have been stated previously in this report.

14 Oct 80
JLK
SWGED-HR

INSTREAM FLOW PROBLEMS AND NEEDS EVALUATION

BARKER RESERVOIR, TEXAS

1. Project Name: Buffalo Bayou and Triburaries, Texas - Barker Reservoir

2. Project Location: River mile 1.3 on South Mayde Creek, tributary to Buffalo Bayou, tributary to the San Jacinto River. Project watershed (130 square miles) located in the State of Texas; downstream water management control station located in Texas.

3. Type of Project:

a. General category: Single purpose detention reservoir (flood control).

b. Storage allocations:

	Elevation (Feet, MSL)	CAPACITY Acre-feet (Thousands)	Inches of Runoff
Minimum Pool	74.0	0	0
Top Flood Control Pool	106.0	209.0	30.2

c. Hydropower category: Not applicable.

d. Outlet works:

Type of Outlet	Number and Size	Invert Elev. (ft.)	Opening Size and Control	Maximum Discharge - Top Flood Control Pool (cfs)
Conduits	5 - 9' wide x 7' high x 190.5' long	73.2	4 gates, 9'x11' 2 gates, 3.5'x9'	9,080

4. Water Management Criteria:

a. Authorized project purpose: Flood control.

b. Water use contracts: Not applicable.

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c. Interagency agreements: None.

d. Informal commitments: None

e. System operation: Barker Reservoir is operated as a part of a flood control system with the adjacent Addicks Reservoir. Essentially, the gates are partially open to pass all normal flow up to 300 to 500 cfs at each dam. With the commencement of a flood condition below the reservoirs and a rising pool level within the reservoirs, the gates on both dams are completely closed. The gates are kept closed until flows below the dams have subsided to normal or until the pool levels rise to such an extent as to require operation under emergency operation schedules.

5. Project Evaluation:

a. Effects of impoundment on water stored:

(1) Positive effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. Impoundment of storm runoff also results in improvements of the quality of water related to utilization of oxygen demanding wastes, and decreases in the variations in the concentrations of dissolved constituents and total nutrients.

(b) Quantity: None.

(2) Negative effects:

(a) Quality: The impoundment of storm runoff results in minor hydrogen sulfide odor problems and increased fecal coliform content.

(b) Quantity: None.

(3) Cause of negative effects: Lengthy storage of flood water in normally empty reservoirs and possible improper operation of wastewater treatment facilities of the rapidly growing urban area upstream of the reservoir.

b. Project effects on instream flows:

(1) General: Discharge frequency and duration curves of regulated flows as well as natural flows are shown on plates 1 through 24.

(2) Positive effects: Although data are limited, present indications are that by maintaining low releases and being selective in gate operation, the dissolved oxygen level in the releases has been increased.

(3) Negative effects: None.

6. Constraints on Obtaining Instream Quantity and Quality Objectives: None.

7. Alternatives:

a. Reservoir regulation: No changes are expected related to instream flow needs.

b. Structural modification: No improvements are expected related to instream flow needs.

c. Storage reallocation: None.

8. Actions Taken to Date: No actions have been taken to date in reference to instream flow problems and needs.

9. Planned Actions: No actions are planned which would affect instream flow problems and needs.

14 Oct 80
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INSTREAM FLOW PROBLEMS AND NEEDS EVALUATION

ADDICKS RESERVOIR, TEXAS

1. Project Name: Buffalo Bayou and Tributaries, Texas - Addicks Reservoir

2. Project Location: River mile 49.8 on Buffalo Bayou, tributary to the San Jacinto River. Project watershed (136 square miles) located in the State of Texas; downstream water management control station located in Texas.

3. Type of Project:

   a. General category: Single purpose detention reservoir (flood control).

   b. Storage allocations:

	Elevation (Feet, MSL)	CAPACITY Acre-feet (Thousands)	Inches of Runoff
Minimum Pool	71.0	0	0
Top Flood Control Pool	112.0	200.8	27.7

   c. Hydropower category: Not applicable.

   d. Outlet works:

Type of Outlet	Number and Size	Invert Elev. (Ft.)	Opening Size and Control	Maximum Discharge - Top Flood Control Pool (cfs)
Conduits	5 - 8' wide x 6' high x 252' long	71.1	4 gates, 8'x10' 2 gates, 3'x 8'	7,780

4. Water Management Criteria:

   a. Authorized project purpose: Flood control.

   b. Water use contracts: Not applicable.

   c. Interagency agreements: Not applicable.

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d. Informal commitments: Not applicable.

e. System operation: Addicks Reservoir is operated as a part of a flood control system with the adjacent Barker Reservoir. Essentially, the gates are partially open to pass all normal flow up to 300 to 500 cfs at each dam. With the commencement of a flood condition below the reservoirs and a rising pool level within the reservoirs, the gates on both dams are completely closed. The gates are kept closed until flows below the dams have subsided to normal or until the pool levels rise to such an extent as to require operation under emergency operation schedules.

5. Project Evaluation:

a. Effects of impoundment on water stored:

(1) Positive effects:

(a) Quality: Impoundment plays a significant role in reducing turbidity associated with storm runoff. Impoundment of storm runoff also results in improvements of the quality of water related to utilization of oxygen demanding wastes, and decreases in the variations in the concentrations of dissolved constituents and total nutrients.

(b) Quantity: None.

(2) Negative effects:

(a) Quality: The impoundment of storm runoff results in minor hydrogen sulfide odor problems and increased fecal coliform content.

(b) Quantity: None.

(3) Cause of negative effects: Lengthy storage of flood water in normally empty reservoirs and possible improper operation of wastewater treatment facilities of the rapidly growing urban area upstream of the reservoir.

b. Project effects on instream flows:

(1) General: Discharge frequency and duration curves of regulated flows as well as natural flows are shown on plates 1 through 24.

(2) Positive effects: Although data are limited, present indications are that by maintaining low releases and being selective in gate operation, the dissolved oxygen level in the releases has been increased.

(3) Negative effects: None.

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6. Constraints on Obtaining Instream Quantity and Quality Objectives: None.

7. Alternatives:

a. Reservoir regulation: No changes are expected related to instream flow needs.

b. Structural modification: No improvements are expected related to insream flow needs.

c. Storage reallocation: None.

8. Actions Taken to Date: No actions have been taken to date in reference to instream flow problems and needs.

9. Planned Actions: No actions are planned which would affect instream flow problems and needs.

WHITNEY LAKE, TEXAS

1. Project Name: Whitney Lake

2. Project Location: River mile 442.4 on the Brazos River. The project watershed (17,656 square miles contributing 8,950 square miles noncontributing) is located in the State of Texas and the downstream water management control stations are located in Texas.

3. Type of Project:

a. General Category: Multiple-purpose storage lake (including hydropower).

b. Storage Allocations and Other Pertinent Data: See Exhibit 1. A total of approximately 627,100 acre-feet of storage has been provided in Whitney Lake below elevation 533.0 feet n.g.v.d., the top of power pool and spillway crest. This storage is for power head and accumulation of sediment. Of this storage approximately 50,000 acre-feet of storage is being contracted for by the Brazos River Authority for water supply use.

c. Hydropower Category: Peak load hydroelectric power generation.

4. Water Management Criteria:

a. Authorized Project Purposes: Flood control, water supply, hydropower, streamflow regulation, and recreation by 711 program.

b. Water Use Contracts: Whitney Lake has no present contract for water supply storage. However, the Brazos River Authority has requested the use of 50,000 acre-feet, or 12.923 percent, of the storage space between elevations 510.0 feet n.g.v.d. and 533.0 feet n.g.v.d. The sale of power generated by the project is administered by the Southwestern Power Administration and the power distributed by the Brazos Electric Power Cooperative, Inc., Waco, Texas. When the Lake is below elevation 520.0, scheduled power releases will be made in accordance with requests by the authorized dispatcher of the Brazos Electric Power Cooperative, Inc. Under the contract, the cooperative furnishes the Government a written statement about the 23rd of each month setting forth the amount of primary energy scheduled for the following month. No rule curve has been approved for operation of the power pool. Inflow to the reservoir due to contractual releases by the Brazos River Authority from Possum Kingdom Reservoir for

LOCATION: R.M. 442.4 on the Brazos River, 5.5 miles southwest of Whitney, Texas, and about 38 miles upstream from Waco, Texas

DRAINAGE AREA
17,656 square miles contributing
8,950 square miles noncontributing
One inch of runoff 941,653 ac-ft

DAM:

Type:	Conc gravity and rolled earth fill
Length:	
Concrete section:	1,674'
Total:	17,695' (including conc sec & 7,820 feet of dikes)
Maximum Height:	159'
Top Width:	
Enbankment:	34'
Spillway:	28'

SPILLWAY:

Crest Elev:	533.0
Length:	680' net at crest
Type:	Ogee
Control:	17 - 40'x38' tainter gates

LOW-FLOW OUTLETS:

Type:	16 conduits through base of concrete dam
Dimension:	5'x9'
Inverts Elev:	448.83

Release Versatility: Control down to approx. 10-20 c.f.s.

POWER FEATURES:

Capacity:	30,000 KW
No. of Units:	2-15,000 KW

NOTE: Area-capacity data based on 1959 sedimentation resurvey of reservoir.

Feature	Elev Feet (msl)	Reservoir Area (acres)	Reservoir Capacity: Accumulative (ac-ft)	Reservoir Capacity: Runoff (inches)	Reservoir Capacity: Incremental (ac-ft)	Spillway Capacity* (cfs): 1 gate	Spillway Capacity* (cfs): 17 gates	Conduit Capacity* (cfs): 1 conduit	Conduit Capacity* (cfs): 16 conduits
Top of Concrete Dam	584.0								
Top of Earth Embankment	580.0								
Maximum Design Water Surface	573.0	51,190	2,100,400	2.23		40,200	684,000		
Top of Flood Control Pool	571.0	49,820	1,999,500	2.12	1,372,400	37,200	632,000	3,000	46,400
Top of Power Pool and Spillway Crest	533.0	23,560	627,100	0.67		0	0	2,600	40,500
Invert of Lowest Intake	448.83	475	4,270						
Power Hd and Sediment Storage					627,100				
Total Storage					1,999,500				
Streambed	425.0								

* Based on model studies

(IN OPERATION)

WHITNEY LAKE

(May 1977)

Exhibit 1

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downstream irrigators will be scheduled as power releases insofar as practicable. Whenever contractual releases (from Possum Kingdom Reservoir) are in progress and power cannot be scheduled by the power company, the inflow at Whitney Reservoir will be released through the conduits.

c. Interagency Agreements: None

d. Informal Commitments: None

e. Systems Regulation Objectives: The plan for regulation of the Basin's Corps of Engineers Lake projects is described in general terms. The storage of water is controlled at projects independently to satisfy conservation needs of each local area except in the case of Whitney where power releases are partially dependent on releases made at the Brazos River Authority Possum Kingdom hydropower project. Flood control releases from all of the projects are made on a system basis to furnish flood protection to the basin as a whole. Maximum release rates for each project, pertinent channel capacities, and travel time between streamgage control stations are all considered in effectively controlling floods within the Brazos River Basin.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: The impoundment tends to play a significant role in reducing the turbidity and suspended sediments associated with storm water runoff. The long-term effect of the impoundment is to act as a detention basin, tending to smooth out sharp variations in chemical quality in the Brazos River waters. The limited sampling conducted at the lake indicates that the quality of the water is generally good, except for concentrations of chlorides and sulfates.

(b) Quantity: The impoundment tends to moderate the daily flow volumes passing the damsite by reducing the high flows. Planned operation of the project insures a more uniform streamflow during flood periods than would exist under natural conditions. The project has greatly increased the water available for beneficial uses such as water supply, recreation, lake fishing, and hydroelectric power generation.

(2) Negative effects: Thermal stratification of the lake waters begins to develop in March and persists until September or October. The thermal stratification results in some seasonal and areal variations in chemical constituent concentrations. During the period of greatest stratification the dissolved oxygen in the hypolimnion decreases and is often zero at the bottom of the lake. This decrease in dissolved oxygen means that the portion of the lake capable of sustaining fish life for an extended period is limited to the top 30 to 40 feet of depth during the summer months. The lake experiences some localized eutrophication conditions during the summer months near the mouth of the Nolands River tributary and near the mouth of the Whitney Creek tributary. Localized algal growths are evident during the summer. The recreation and beach areas occasionally have elevated coliform counts during heave use periods. The limited data available indicates occasional elevated chloride and sulfate concentrations are experienced.

(3) Causes of negative effects: The thermal stratification pattern of the impounded waters is the main cause of any degradation in the quality of the water in Whitney Lake. The elevated levels of chloride and sulfate concentrations is caused by the poor quality inflow under which is seriously degraded by emissions from major natural salt sources in the upper Brazos River Basin. The mineral pollutants consist principally of sodium chloride and calcium sulfate. The Nolands River and Whitney Creek tributaries both carry treated effluent from upstream sewage treatment plants. The poor quality of this inflow water is the main cause of any summer localized eutrophic conditions and localized algal growths. Most of the land around the lake is taken up by public parks and recreation areas. A few small housing developments exist which could be potential sources of wastewater from improperly constructed septic tanks or runoff but no complaints have been made.

b. <u>Project Effects on Instream Flows</u>:

(1) General: Monthly flow volume frequency and duration curves for flows immediately downstream of the project under pre- and post-impoundment conditions are shown on Plates 1 through 24. It should be noted that the periods of record are different. The power facilities at the project include two generation units. The facilities generate on demand to meet peak load power demands and therefore may or may not use both units at one time. The average monthly hours of part load generation for the period 1970 to 1980 was 330 hours, the remaining time was no generation time.

Inflow to the reservoir due to contractual releases by the Brazos River Authority from Possum Kingdom Reservoir for downstream use will be scheduled as power releases insofar as practicable. Whenever contractual releases (from Possum Kingdom Reservoir) are in progress and power cannot be scheduled by the power company, the inflow at Whitney Lake will be released through the conduits as required.

(2) Positive effects: The Whitney Dam project generally tends to help smooth the peak flood flows of the Brazos River Basin and to reduce downstream flood damages. The project has greatly improved the low-flow volume conditions below the project during the middle and late summer by decreasing the number of days of zero flow passing the dam. The coordinated releases from Possum Kingdom Reservoir have provided hydroelectric energy and water supply for irrigation.

(3) Negative effects: Analysis of the quality of the water immediately below the dam indicates that several parameters are often outside the recommended Texas Water Quality Standards. The data indicates that there is a serious problem with respect to dissolved solids, chlorides, and sulfate concentrations. Of 65 test samples 10 samples showed dissolved solids concentrations in excess of the recommended 1,200 mg/l, 33 samples showed chloride concentrations in excess of the recommended 400 mg/l, and 30 samples showed sulfate concentrations in excess of the recommended 200 mg/l. The dissolved solids of the samples ranged from 696 mg/l to 2,150 mg/l with a mean of 1,068 mg/l and a standard deviation of 234 mg/l. The chloride concentrations of the samples tested ranged from 240 mg/l to 870 mg/l with a mean concentration of 400 mg/l and a standard deviation of 97 mg/l. The sulfate concentrations ranged from 110 mg/l to 460 mg/l with a mean concentration of 209 mg/l and a standard deviation of 62 mg/l. Since hydroelectric power releases are made upon demand there are sudden variances in the tailwater and downstream flow volumes.

(4) Cause of negative effects: Any degradation in the quality of the water downstream of Whitney Dam can be attributed to the presence of the dam, the thermal stratification of the impounded waters, the lack of a multiple level low-flow release capability, and the degraded quality of the inflow waters. Since the project releases low-flows from only one level, the poorer quality hypolimnion, the downstream water is adversely effected, especially during the summer. Fluctuations in the tailwater and downstream flow volumes is caused by the hydropower releases which are made upon demand to meet peak load power requirements.

c. Project Effect on System Regulation: The projects in the Brazos River Basin are operated for flood control, water conservation, hydropower generation, and for other beneficial uses of the basin surface runoff waters. The storage of water is controlled at projects independently to satisfy conservation needs of each local area except in the case of Whitney where power releases are partially dependent on releases made at the Brazos River Authority Possum Kingdom hydropower project. Flood control releases from all of the projects are made on a system basis to furnish flood protection to the basin as a whole. The improper operation of any project may cause detrimental effects to the immediate area below the project as well as to the basin as a system. Whitney operations have the potential of adversely effecting hydropower, flood protection and the quality of the downstream waters.

6. Constraints on Obtaining Instream Quality and Quantity Objectives: The quality of the inflow waters is seriously degraded by natural salt emissions in the upper basin area. The project tends to concentrate the levels of chorides and sulfates in the lower levels of the lake waters. The project releases, which can only be made from the lower level hypolimnion, therefore, adversely effect the quality of the downstream flows. The low-flow release rates are partially dependent on the releases from Possum Kingdom Reservoir and the demand for peak load power. The project releases can only be controlled down to a minimum of about 10 to 20 c.f.s. and the higher release rates controlled to within plus or minus 10 c.f.s.

7. Alternatives:

a. Reservoir Regulation: None proposed.

b. Structural Modification: None proposed.

c. Storage Reallocation: None proposed.

8. Actions Taken to Date: The Fort Worth District has conducted three meetings with the U.S. Fish and Wildlife Service in connection with flow maintenance downstream of the Fort Worth District projects. Inasmuch as the U.S. Fish and Wildlife Service agrees with the Fort Worth District's assessment that releases from Whitney Dam are satisfactory considering the project purposes and the constraints discussed in paragraph 6, no additional study for flow maintenance will be made.

9. Planned Actions: None planned. The Fort Worth District is, however, in the process of evaluating the need to update the hydropower operating rule curve. If the rule curve is changed then the Water Control Manual will be updated with respect to hydropower operations.

WACO LAKE, TEXAS

1. Project Name: Waco Lake

2. Project Location: River mile 4.6 on Bosque River, Brazos River Basin. The project watershed (1,670 square miles) is located in the State of Texas and the downstream water management control stations are located in Texas.

3. Type of Project:

a. General Category: Multiple-purpose storage lake (excluding hydropower).

b. Storage Allocations and Other Pertinent Data: See Exhibit 1. The total storage below the top of conservation pool, elevation 455.0 feet, n.g.v.d., is approximately 152,500 acre-feet. Of this approximately 48,400 acre-feet is allocated for sediment accumulation and approximately 104,100 acre-feet is allocated for water supply. See paragraph 4b for water supply use contracts.

c. Hydropower Category: N/A

4. Water Management Criteria:

a. Authorized Project Purposes: Flood control, water supply and recreation by 711 program.

b. Water Use Contracts: The Brazos River Authority has contracted for 87,487 percent (91,074 acre-feet) of the available water supply storage and the City of Waco has contracted for the remaining 12.513 percent (13,026 acre-feet) of water supply storage.

c. Interagency Agreements: None

d. Informal Commitments: None

e. Systems Regulation Objectives: Waco Dam is part of a system of reservoirs for controlling the floodwaters on the lower Bosque River and the lower Brazos River. Downstream releases must be coordinated in order to prevent downstream damages and excessive deterioration of the downstream waters.

5. Project Evaluation:

LOCATION: In McLennan County, R.M. 4.6 on Bosque River, Brazos River Basin, contiguous to city limits of Waco, Texas.

DRAINAGE AREA:
1,670 square miles
One inch of runoff - 89,067 acre-feet

DAM:
Type: Earth fill with concrete spillway left bank
Length: 24,618' (including spillway)
Maximum Height: 140'
Top Width:
Embankment: 20'
Nonoverflow: 16'

SPILLWAY:
Crest Elev: 465.0
Length: 560' net at crest
Type: Ogee
Control: 14-40'x35' tainter gates

INFLOW:
Spillway design flood peak, cfs 622,900
Spillway design flood volume, ac-ft 1,831,500
Spillway design flood runoff, inches 20.56

OUTFLOW (Elev 505.0):
Total routed peak outflow, cfs 584,200
Spillway 563,300
Outlet works 20,900

OUTLET WORKS:
Type: 1 conduit
Dimension: 20' diameter
Invert Elev: 400.0
Control: 3-6'8"x20' broome-type tractor sluice gates

OUTLET WORKS: LOW FLOW
Type & Dimension: 2 conduits, 54" diameter
Intake Elev: 1 each @408.0, 424.0, 440.75, 445.0
Control: 4 - 5'x6' sluice gates
Release versatility: Control down to approx 10 c.f.s.

Feature	Elev Feet (msl)	Reservoir Area (acres)	Reservoir Capacity: Accumulative (ac-ft)	Runoff (inches)	Incremental (ac-ft)	Low-Flow Capacity (cfs)	Outlet Works Capacity (cfs)
Top of dam	510.0						
Maximum design water surface	505.0	21,390	828,300	9.30			20,900
Top of flood control pool (or top of gates)	500.0	19,440	726,400	8.16	553,300	640	20,100
Spillway crest	465.0	9,220	233,500	2.62			15,100
Top of conservation pool	455.0	7,270	152,500	1.71	104,100	520	13,400
Sediment reserve					69,000*		
Total storage (controlled)					726,400		
Maximum tailwater	431.6						
Streambed	370.0						

* Sediment distributed as follows: Between elev 445.0 and 500.0 - 20,600 ac-ft.
Between elev 427.0 and 455.0 - 34,000 ac-ft.
Below elev 427.0 - 14,400 ac-ft.

(IN OPERATION)

(May 1977) WACO LAKE

Exhibit 1

a. <u>Effects of Impoundment on Water Stored</u>:

(1) Positive effects:

(a) Quality: The impoundment of water behind Waco Dam tends to reduce any turbidity associated with storm runoff especially from the large agricultural area of the South Bosque River. The structure is also responsible for trapping sediment and nutrients associated with the upstream runoff. Analysis of the existing data indicates that the quality of the impounded water is generally good. It should be noted that the City of Waco operates two bubble type aerators, one near the outlet structure and one on the North Bosque, to help improve the dissolved oxygen in the lake. The two aerators have essentially distratified the lake. Prior to the use of the aerators the dissolved oxygen in the hypolimnion would be depleted to zero during the summer months causing taste, odor, and problems in the treatment of the water for domestic use.

(b) Quantity: The project has greatly increased the quantity of water available for beneficial uses such as water supply, lake recreation, and lake fishing.

(2) Negative effects: The lake periodically experiences increased algal growth especially in the vicinity of the aerators and in the headwater areas. The upper end of the lake where the North Bosque and South Bosque enter the lake occasionally experience high fecal coliform counts and high nutrient loadings. The lake water occasionally becomes highly turbid, especially after a heavy rain.

(3) Causes of negative effects: The City of Waco and the Brazos River Authority have wastewater treatment plant located upstream of the project which occasionally dump raw sewage causing increased nutrient loadings and increased fecal coliform populations. The large agricultural runoff of the South Bosque River causes increased turbidity especially after a heavy rain. The operation of aerators by the City of Waco causes an environment conducive to increased algal growth.

b. <u>Project Effects on Instream Flows</u>:

(1) General: Monthly flow volume frequency and duration curves for flows immediately downstream of the Waco Dam project under pre- and post-impoundment conditions are shown on Plates 1 through 24. It should be noted that the periods of record for the two conditions are different.

(2) Positive effects: The Waco Dam reduces the peak flood flows downstream of the project by controlling the upstream watershed runoff. This helps to reduce the downstream damages that would have otherwise occurred. The quality of the release waters and its effects on the downstream conditions is unknown as the releases are not monitored.

(3) Negative effects: The Waco Dam project has generally increased the number of days of zero flow passing the damsite, especially during the summer months. Since the quality of the water passing through the dam is not monitored it is not known what impact the release waters have on the downstream reach. The Brazos River backs up against the Waco Dam and has proven to be able to support a good fishery.

(4) Cause of negative effects: Any degradation in the quality of the water directly below Waco Dam can be attributed to the quality of the release waters and to the quality of the Brazos River backwaters. Since the water supply releases for the City of Waco are not released downstream but through a pipeline to a treatment facility the number of days of zero flow passing downstream has increased.

c. Project Effects on System Regulation: The Waco Dam project is part of a system of dams and lakes for controlling the flood waters on the lower Bosque River and the lower Brazos River. Waco Dam is responsible for control of the lower Bosque River. Coordination of the Federal and non-Federal projects must be maintained to prevent flood damages, excessive degradation of the quality of the water, and deterioration of the downstream fishery.

6. Constraints on Obtaining Instream Quality and Quantity Objectives:

a. Quality: The quality of the inflow waters is periodically degraded due to raw sewage dumping by the City of Waco and by the Brazos River Authority wastewater treatment plants. This by-pass dumping usually has a short term detrimental effect upon the quality of the impounded waters. The large agricultural runoff of the South Bosque River watershed similarly causes limited degradation in the quality of the lake water and causes an increase in the turbidity. The degraded inflow waters and the subsequent effect on the impounded waters may cause some degradation to the downstream quality.

b. Quantity: The State of Texas claims the rights to the waters within its boundaries and requires a using agency to obtain a permit to use the water. Historically the State of Texas has not required the

City of Waco or the Brazos River Authority to make a guaranteed minimum downstream release from Waco Dam. Since conservation releases usually are taken by pipeline from the low-flow outlet works and do not pass downstream the number of days or zero flow has increased since impoundment. The low-flow outlet works is only capable of making a minimum release of about 10 c.f.s. with higher rates within an accuracy of plus or minus 5 c.f.s.

7. Alternatives:

a. Reservoir Regulation: None proposed.

b. Structural Modification: A study is in progress to determine the feasibility of increasing the water supply storage. One proposal is to raise the dam thus adding water supply storage that could be used by the City of Waco. The estimate of cost for the structural modification has not been finalized. See paragraph 7c for an additional proposal.

c. Storage Reallocation: A study is in progress to determine the feasibility of increasing the water supply storage available in Waco Lake by reducing the allocated flood control storage. The flood control storage would be transferred to a proposed damsite upstream of Waco Lake. The cost estimate for the reallocation and the construction of a new dam has not been finalized.

8. Actions Taken to Date: The Fort Worth District has conducted three meetings with the U.S. Fish and Wildlife Service in connection with flow maintenance downstream of the Fort Worth District projects. Inasmuch as the U.S. Fish and Wildlife Service agrees with the Fort Worth District assessment that releases are satisfactory at Waco Dam, no additional study for flow maintenance is planned.

9. Planned Actions: None proposed.

PROCTOR LAKE, TEXAS

1. Project Name: Proctor Lake

2. Project Location: River mile 238.9 on Leon River, tributary to Little River, Brazos River Basin. The project watershed (1,265 square miles) is located in the State of Texas and the downstream water management control stations are located in Texas.

3. Type of Project:

a. General Category: Multiple-purpose storage lake (excluding hydropower).

b. Storage Allocations and Other Pertinent Data: See Exhibit 1. The total storage below the top of conservation pool, elevation 1,162.0 feet n.g.v.d., is approximately 59,400 acre-feet. Of this approximately 28,000 acre-feet is allocated for sediment accumulation and approximately 31,400 acre-feet is allocated for water supply. See paragraph 4b for a discussion of contracts for water supply.

c. Hydropower Category: N/A

4. Water Management Criteria:

a. Authorized Project Purposes: Flood control, water supply, and recreation under the 711 program.

b. Water Use Contracts: The Brazos River Authority has contracted for approximately 31,400 acre-feet, or 100 percent, of the storage available for water supply below top of conservation pool, elevation 1,162.0 n.g.v.d.

c. Interagency Agreements: None.

d. Informal Commitments: None.

e. Systems Regulation Objectives: Proctor Dam is located on the main stem of the Leon River, 238.9 river miles upstream from its confluence with the Little River. The Little River flows into the

LOCATION: R.M. 238.9 on Leon River, Brazos River Basin near Proctor, Texas, and about 8 miles northeast of Comanche, in Comanche County.

DRAINAGE AREA:
1,265 square miles
One inch of runoff - 67,467 acre-feet

DAM:
Type: Earth fill with concrete spillway in right abutment ridge
Length: 13,460' (including spillway)
Maximum Height: 86'
Top Width: 30'

SPILLWAY:
Crest Elevation: 1162.0
Length: 440' net at crest
Type: Ogee
Control: 11-40'x35' tainter gates

INFLOW:

Spillway design flood peak, cfs	459,200
Spillway design flood volume, ac-ft	1,443,200
Spillway design flood runoff, inches	22.09

OUTFLOW (Elevation 1201.0):

Total routed peak outflow, cfs	432,400
Spillway	431,800
Outlet Works	600

OUTLET WORKS, LOW-FLOW:
Type: 2 gate controlled conduits
Dimension: 36" diameter
Invert Elevation: 1128.0
Control: 2-36" diameter slide gates
Release Versatility: Control down to approx. 5-10 c.f.s.

Feature	Elev Feet (msl)	Reservoir Area (acres)	Reservoir Capacity: Accumulative (ac-ft)	Reservoir Capacity: Runoff (inches)	Reservoir Capacity: Incremental (ac-ft)	Spillway Capacity (cfs)	Outlet Works Capacity (cfs)
Top of dam	1206.0						
Maximum design water surface	1201.0	15,410	433,000	6.42		431,800	600
Top of flood control pool (or top of gates)	1197.0	14,010	374,200	5.55	310,100	361,000	590
Top of conservation pool - spillway crest	1162.0	4,610	59,400	0.88	31,400	0	410
Sediment reserve					32,700*		
Total storage					374,200		
Maximum tailwater	1172.7						
Streambed	1120.0						

* Sediment distributed as follows: 28,000 ac-ft below elev 1162.0
4,700 ac-ft between elev 1162.0 and 1197.0

(IN OPERATION)

PROCTOR LAKE

(May 1977)

Exhibit 1

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Brazos River at river mile 315.8. Proctor Lake is part of a system of lakes for controlling the floodwaters on the Little River watershed. Proctor Lake controls the floods on the upper Leon River; Belton Lake the floods on the Leon River; Stillhouse Hollow Lake the floods on the Lampasas River; and Georgetown and Granger Lakes the floods on the San Gabriel River. These projects in coordination with Whitney Lake on the Brazos River, Waco Lake on the Bosque River, and Somerville Lake on Yegua Creek form a system of lakes for controlling flows and reducing damages on the Brazos River.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: Available data indicates that the quality of the water impounded by Proctor Dam is generally good. The project acts as a sediment retarding structure and tends to reduce the turbidity of storm runoff. The project tends to moderate large fluctuations in quality constituents.

(b) Quantity: The project generally reduces the flood flows of the watershed. The project has greatly increased the quantity of water available for beneficial uses such as water supply, lake recreation, and lake fishing.

(2) Negative effects: The lake tends to develop a mild thermal stratification during the months of June, July, and August. During this period the hypolimnion waters are gradually depleted of dissolved oxygen and only about the top 30-35 feet of the lake is capable of sustaining fish and invertebrate life for an extended period of time. Available data indicates that the pH and the chloride concentration of individual test samples may infrequently exceed the recommended Texas Water Quality Standards. During the summer heavy use of recreation and park areas may cause high coliform counts for short periods. The use of septic tanks at developments near the lake are potential pollution sources during large floods. Increased algae is associated with the aeration system installed near the outlet works.

(3) Causes of negative effects: The impoundment of the Leon River waters by Proctor Dam and the subsequent thermal stratification of the waters are major contributors to the dissolved oxygen depletion and the increase in the pH and chlorides. The aeration system at the outlet works causes an increase in algae.

b. Project Effects on Instream Flows:

(1) General: Monthly flow volume frequency and duration curves for flows immediately downstream of the project under pre- and post-impoundment conditions are shown on Plates 1 through 24. It should be noted that the periods of record for the two conditions are different.

(2) Positive effects: Proctor Dam tends to smooth the peak flood flows and reduce downstream flood damages. The quality of the release waters and the downstream waters is not monitored. It is expected that the release waters are of good quality since an aeration system was installed upstream of the outlet works and a special bulkhead was constructed on one of the low-flow outlets in order to make summer releases from the top 10 feet of the pool.

(3) Negative effects:

(a) Quality: The effects of the project on the downstream quality of water is not known since neither the quality of the downstream waters nor the quality of the water released from Proctor Dam is monitored.

(b) Quantity: A preliminary best-estimate by the Corps of Engineers of instream flow needs on a monthly basis for the Proctor Dam project was computed based on pre-impoundment and post-impoundment periods of record flows. Since the two periods of record differ they should be analyzed to determine natural climatic variations and the preliminary estimates adjusted appropriately. The following represents a composite minimum instream maintenance flow based on pre-impoundment average and pre-impoundment median low flows as determined through the Montana Method and the Modified Tennant's Method respectively.

Month	Flow, c.f.s.	Month	Flow, c.f.s.
JAN	10	JUL	15
FEB	10	AUG	10
MAR	15	SEP	10
APR	50	OCT	10
MAY	100	NOV	10
JUN	50	DEC	10

Since impoundment of Proctor Lake the number of days of zero flow passing the damsite has increased, especially during the summer months. This deterioration in low-flows is detrimental to the instream maintenance flow needs downstream of the project.

(4) Causes of negative effects: Any degradation in the quality and quantity of the downstream flows can be attributed to the presence of Proctor Dam, the subsequent thermal stratification of the impounded waters, and the operation of the low-flow outlet works. The low-flow releases are made upon request by the Brazos River Authority.

c. Project Effects on System Regulation: Proctor Dam is part of a system of lakes for controlling the flood waters on the Little River watershed and for controlling flows and reducing flood damages on the Brazos River. The coordination of flood control releases is necessary to prevent unwarranted damages. Low-flow releases from other than the top 10 feet of the pool, over the special bulkhead, or without aeration during the summer months has the potential of causing fish kills downstream and of causing excess treatment before use as a water supply.

6. Constraints on Obtaining Instream Quantity and Quality Objectives: The State of Texas claims the rights to the waters within its boundaries and requires a using agency to obtain a permit to use the water. Historically the State of Texas has not required the Brazos River Authority to make a guaranteed minimum release from Proctor Dam. The conservation releases are made upon request by the Brazos River Authority who has contracted for all of the available water supply storage. Since impoundment the number of days of zero flow passing the damsite has increased. The releases can only be controlled down to a minimum of about 5 to 10 c.f.s. and higher rates can only be controlled to within plus or minus 10 c.f.s.

7. Alternatives:

a. Reservoir Regulation: The Fort Worth District has conducted three meetings with the U.S. Fish and Wildlife Service in connection with flow maintenance downstream of the Fort Worth District projects. Proctor Lake is one of the projects selected for a detailed study. This study will investigate the feasibility of changing the existing regulation plan for possible improvement in low flow maintenance.

b. Structural Modification: The detailed study will investigate the feasibility of adding a selective withdrawal capability to the outlet works. Since this would only enhance the quality of the releases not the quantity this possibility is limited and would probably be too costly. The quantity of the releases is dependent upon the Brazos River Authority requests.

c. Storage Reallocation: The detailed study will investigate the possibility of reallocating storage for possible improvement in low-flow releases by reducing the number of days of zero flow through the dam. Any reallocation of storage would have to be specifically authorized by amendment by the Congress.

8. Actions Taken to Date: In order to improve the dissolved oxygen of the low-flow releases an aerator was installed with air pumped into the lake water just upstream of the outlet works. A special bulkhead was also constructed on one of the low-flow outlets to allow water to be drawn from the top 10 feet of the lake.

9. Planned Actions: A detailed study of the project will be conducted with emphasis on flow maintenance downstream of the project. The project is one of eight projects for which detailed studies were agreed upon. The eight projects will be studied in downstream order with Proctor Lake being the sixth project studied. The hydrologic and biologic analyses will be performed and operational and structural alternatives investigated for possible improvement in low flow releases. The increase in the number of days of zero flow passing into the downstream channel is the major area of concern with regards to satisfying instream flow maintenance needs. Preliminary study indicates that since all of the available water supply storage is contracted for, either a change in the regulation plan or a storage reallocation is the most feasible approach to satisfying downstream needs. The constraints discussed in paragraph 6 will be considered in the final study. The alternatives evaluated will necessarily take such factors as legal feasibility, downstream and lake fishery, water quality, aesthetics, flood control, water supply, recreation, and periodic shutdowns for maintenance into account. A rough estimate of the cost to complete the studies, including additional hydrologic analyses, environmental analyses, coordination with other agencies, contract negotiations, etc. is $55,000. Schedule for completion of the studies will be dependent on manpower and funds availability. Objectives have been stated previously in this report.

BELTON LAKE, TEXAS

1. Project Name: Belton Lake

2. Project Location: River mile 16.7 on Leon River, tributary to Little River, Brazos River Basin. The project watershed (3,560 square miles) is located in the State of Texas and the downstream water management control stations are located in Texas.

3. Type of Project:

a. General Category: Multiple-purpose storage lake (original authorization was modified to provide the generation of hydroelectric power).

b. Storage Allocations and Other Pertinent Data: See Exhibit 1. The total storage below the top of conservation pool, elevation 594.0 feet n.g.v.d. is approximately 457,600 acre-feet. Of this approximately 84,900 acre-feet is allocated for sediment accumulation and approximately 372,700 acre-feet is allocated for water supply. See paragraph 4b for water use contracts.

c. Hydropower Category: Authorized but not constructed.

4. Water Management Category:

a. Authorized Project Purposes: Flood control, water supply, irrigation, recreation by 711 program and hydroelectric power generation (when advisable).

b. Water Use Contracts: The Brazos River Authority has contracted for approximately 372,700 acre-feet of the available water supply storage below top of conservation pool. Of this, 12,000 acre-feet is allocated to Fort Hood and adjacent military installations for a permanent water supply.

c. Interagency Agreements: Provisions have been made for Fort Hood to withdraw from a special intake structure located about 3 miles upstream of the dam. The water withdrawn is from the 12,000 acre-feet of water supply storage allocated to Fort Hood and adjacent military installations and is designated as a permanent water supply.

d. Informal Commitments: None.

LOCATION: R.M. 16.7 on Leon River, Brazos River Basin, about 3 miles north of Belton, Bell County, TX

DRAINAGE AREA:
3,560 square miles
One inch of runoff 189,867 acre-feet

DAM:
Type: Rolled earth fill
Length: 5,524' (including spillway and 418-foot dike)
Maximum Height: 192'
Top Width: 30'

SPILLWAY:
Crest Elev: 631.0
Length: 1,300'
Type: Ungated broadcrested

OUTLET WORKS:
Type: 1 conduit w/3 gated inlets
Dimensions:
Conduit: 22'
Inlets: 3-7'x22'
Invert Elevation: 483.0
Control: 3-7'x22' broome-type gates

LOW-FLOW OUTLETS:
Type: 1-36"x36" gated outlet discharging into flood control conduit
Invert Elev: 540.0 (at intake to wet well)
Release versatility: Control down to approx 5-10 c.f.s.

POWER FEATURES: FC Act of 1954 authorized modification to provide for generation of hydroelectric power. However, Belton hydro-power project is not justified. Consideration will be given at some future date to deauthorizing the power function.

Feature	Elev Feet (msl)	Reservoir Area (acres)	Reservoir Capacity: Accumulative (acres)	Reservoir Capacity: Runoff (inches)	Reservoir Capacity: Incremental (ac-ft)	Spillway Capacity (cfs)	Outlet Works Capacity (cfs): 1 Int	2 Int	3 Int	Low Flow Outlet Capacity (cfs)
Top of Dam	662.0									
Max Design Water Surface	656.9	37,340	1,876,700	9.88		472,500	13,510	36,890	30,480	640
Top of Flood Control Pool & Spillway Crest	631.0	23,620	1,097,600	5.78	640,000	0	12,300	24,600	27,900	590
Top of Ultimate Conservation Pool	594.0	12,300	457,600	2.41	372,700	0	10,300	20,800	23,600	510
Top of Interim Conserv Pool	569.0	7,400	210,600	1.11		0	8,770	17,900	20,290	450
Invert, Lowest Intake	483.0	42	278	0		0	0	0	0	
Streambed at Dam	470.0	0	0							
Sediment Reserve					84,900					
Total Storage					1,097,600					

(IN OPERATION)

(May 1977)

BELTON LAKE

Exhibit 1

e. Systems Regulation Objectives: The Belton Dam and Lake project is an integral part of the Corps of Engineers plan for flood control on the Lower Brazos River and its tributaries. The plan presently consists of 12 dam and lake projects, of which 6 have been completed and placed in operation. Belton operates with Proctor for flood control on the Leon River, and with Proctor and Stillhouse Hollow for control of Little River floods and Brazos River floods downstream from the Little River confluence. The 12-project system will control flow from *36,830 square miles in the Brazos River Basin of which 9,240 square miles are probably noncontributing while only 7,520 square miles of drainage area will remain uncontrolled. *Of this amount, 3,560 square miles are controlled by Belton.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: The impoundment of water behind Belton Dam tends to reduce the turbidity associated with the storm runoff waters and the dam acts as a sediment retarding structure. Available data indicates that the quality of the impounded waters is generally good and indicates that no significant salinity or salinity-induced stratification problems exist.

(b) Quantity: The impoundment tends to smooth out the flows at the damsite by reducing the peak flows. The project has greatly increased the quantity of water available for beneficial purposes such as water supply, lake recreation, and lake fishing.

2. Negative effects: Thermal stratification of the lake waters begins to develop in early to late March and persists until September or October. The thermal stratification results in significant seasonal and areal variations in dissolved oxygen, dissolved iron, and dissolved manganese. Oxygen utilized in the oxidation of dead organisms and other organic material near the bottom of the lake leads to an anaerobic environment. Consequently, water below a 35 to 40 foot depth usually has less than 1.0 mg/l of dissolved oxygen. Water near the surface usually contains less than .030 mg/l of dissolved iron and .020 mg/l of dissolved manganese which is acceptable for water supply use. During the summer months, however, the dissolved iron concentration at the bottom of the lake near the dam averages about .290 mg/l ranging upwards to .600 mg/l. The dissolved manganese also increases during the summer to an average of about .320 mg/l. The combination of these concentrations is outside the recommended limit for drinking water established by the U. S. Public Health Service.

(3) Causes of negative effects: The thermal stratification pattern of the impounded waters is the main cause of the variance in the quality of the water in Belton Lake. The conservation storage releases were made upon the request of the Brazos River Authority and may vary considerably causing fluctuations in the tailwater.

b. Project Effects on Instream Flows:

(1) General: A comparison of the monthly flow volume frequency and duration curves for the project under pre- and post-impoundment conditions are shown on Plates 1 through 24. It should be noted that the periods of record for the two conditions are not the same.

(2) Positive effects: The Belton Dam project generally tends to smooth the flood water releases and reduce the peak flows passing through the dam by storing storm runoff and releasing the waters at a lower rate over a longer time period, thus reducing downstream damages that would have occurred without the project. The limited data on the quality of the water below Belton indicates that the water is generally of good quality.

(3) Negative effects:

(a) Quality: Hydrogen sulfide odors are occasionally evidenced with the project releases during the summer months. At this time the dissolved oxygen concentration in the release water can be expected to be slightly depressed and the dissolved iron and manganese slightly increased. The data indicates that only one test sample did not meet the recommended Texas Water Quality Standards.

(b) Quantity: A preliminary best-estimate by the Corps of Engineers of instream flow needs on a monthly basis was computed using pre- and post-impoundment period of record flows for the project. Since the two periods of record differ they should be analyzed to determine natural climatic variations and the preliminary estimates adjusted appropriately. The following represents a composite instream maintenance flow based on pre-impoundment average and pre-impoundment median low flows as determined through the Montana Method and Modified Tennant's Method respectively.

Month	Flow, c.f.s.	Month	Flow, c.f.s.
JAN	65	JUL	65
FEB	65	AUG	40
MAR	125	SEP	65
APR	250	OCT	60
MAY	250	NOV	50
JUN	125	DEC	65

Since impoundment of Belton Lake the number of days of zero flow passing the damsite has increased, especially during the summer months. This increase appears to be detrimental to the propagation of fish downstream of the project.

(4) Cause of negative effects: Any degradation in the quality of the water directly below Belton Dam can be attributed to the presence of the project, the subsequent thermal stratification of the impounded waters, and the lack of a multiple level low-flow release facility at the project. Since the project can release low-flow from only one level the quality of the release waters can not be adequately controlled. The State of Texas claims the rights to the waters within its boundaries and requires a using agency to obtain a permit to use the water. Historically, the State of Texas has not required Brazos River Authority to make a guaranteed minimum release from Belton Dam. Since conservation releases from the project are made upon request by Brazos River Authority the number of days of zero flow has increased since impoundment.

c. Project Effects on System Regulation: The Belton Dam and Lake project is an integral part of the plan for flood control on the Lower Brazos River and its tributaries. Belton Dam operates in conjunction with Proctor Dam for flood control on the Leon River, and with Proctor Dam and Stillhouse Hollow Dam for control of Little River and Brazos River floods. Coordinated releases are important for flood control and for maintaining quality flow in the Brazos River system.

6. Constraints on Obtaining Instream Quantity and Quality Objectives: The project lacks a multiple level withdrawal system for low flows, thus conservation releases were made from the poorer quality hypolimnion waters. The State of Texas claims the rights to the waters within its boundaries and requires a using agency to obtain a permit to use the water. Historically, the State of Texas has not required the Brazos River Authority to make a guaranteed minimum release from Belton Dam, therefore, the number of days of zero flow has increased. The flow rates from Belton Dam can only be controlled down to about 5 to 10 c.f.s. and larger flow rates controlled to plus or minus 10 c.f.s.

7. Alternatives:

a. Reservoir regulation: The Fort Worth District has conducted three meetings with the U. S. Fish and Wildlife Service in connection with flow maintenance downstream of the Fort Worth District projects. It was agreed that Belton Dam and Lake would be one of eight projects that would be studied in greater detail. The study will include the feasibility of changing the regulation plan for possible improvement in low flow releases.

b. Structural Modification: See paragraph 9.

c. Storage reallocation: The detailed study will investigate the possibility of reallocating storage for possible improvement in low flow releases in an attempt to increase the low flow through the dam. Any reallocation of storage would have to be specifically authorized by amendment by the Congress.

d. Other: None proposed.

8. Actions Taken to Date: The Fort Worth District has conducted three meetings with the U. S. Fish and Wildlife Service to discuss possible improvement of low flow releases from the Fort Worth District projects. A detailed study on Belton Lake was agreed upon and will be coordinated with the U. S. Fish and Wildlife Service. This study will include hydraulic and hydrologic investigations and analysis of structural and non-structural alternatives including costs.

9. Planned Actions: A detailed study of the project will be conducted with emphasis placed on flow maintenance downstream of the project. The project is one of eight projects for which detailed studies will be conducted. The eight projects will be studied in downstream order with Belton Lake being the seventh project studied. Hydrologic and biologic analyses will be conducted and operational and structural alternatives investigated for possible improvement in low flow releases. The increase in the number of days of zero flow passing into the downstream channel is the major area of concern with regards to satisfying instream flow maintenance needs. Preliminary study indicates that since all of the available water supply storage is contracted for, either a change in the regulation plan or a storage reallocation is the most feasible approach to satisfying downstream needs. The constraints discussed in paragraph 6 will be considered in the final study. The alternatives evaluated will necessarily take such factors as legal feasibility, downstream and lake fishery, water quality, aesthetics, flood control, water supply, recreation, and periodic shutdowns for maintenance into account. A rough estimate of the cost to complete the studies, including additional hydrologic analyses, environmental analyses, coordination with other agencies, contract negotiations, etc. is $50,000. Schedule for completion of the studies will be dependent on manpower and funds availability. Objectives have been stated previously in this report.

STILLHOUSE HOLLOW LAKE, TEXAS

1. Project Name: Stillhouse Hollow

2. Project Location: River mile 16.0 on Lampasas River, tributary to the Little River, Brazos River Basin. The project watershed (1,318 square miles) is located in the State of Texas.

3. Type of Project:

a. General Category: Multi-purpose storage lake (excluding hydropower).

b. Storage Allocations and Other Pertinent Data: See Exhibit 1. The total storage below the top of conservation pool, elevation 622.0 feet n.g.v.d., is approximately 235,700 acre-feet. Of this approximately 30,800 acre-feet is allocated for sediment accumulation and approximately 204,900 acre-feet is allocated for water supply. See paragraph 4b for discussion of contracts for water supply.

4. Water Management Criteria:

a. Authorized Project Purposes: Flood control, water supply, and recreation by 711 program.

b. Water Use Contracts: Brazos River Authority has contracted for 204,900 ac-ft, or 100 percent, of the available water supply storage below top of conservation pool, elevation 622.0 feet n.g.v.d.

c. Interagency Agreements: None

d. Informal Commitments: None

e. Systems Regulation Objectives: The Stillhouse Hollow Dam and Lake project is an integral part of the Corps of Engineers plan for flood control on the Lower Brazos River and its tributaries. Stillhouse Hollow Dam operates with Proctor Dam and Belton Dam for control of the Little River floods and the Brazos River floods downstream from the Little River confluence. Stillhouse Hollow Dam controls the floods on the Lampasas River, North Fork and Granger Dams; the floods on the San Gabriel River, Whitney Dam; the floods on the Brazos River, Waco Dam; the floods on the Bosque River, and Somerville Dam; the floods on Yegua Creek. These dams form a system for controlling flooding and for controlling the surface water resources of the Brazos River Basin for beneficial uses.

LOCATION: R.M. 16.0 on Lampasas River, Brazos River Basin, 5 miles southwest of Belton, Bell County, TX

DRAINAGE AREA:
1,318 square miles
One inch of runoff 70,293 ac-ft

DAM:
Type: Earth fill
Length: 15,624' (including spillway & dike)
Maximum Height: 200'
Top Width: 42' (dike 10')

SPILLWAY:
Crest Elev: 666.0
Length: 1,650' net at crest
Type: Broadcrested, ungated

INFLOW:

Spillway design flood peak, cfs	766,600
Spillway design flood volume, ac-ft	1,585,700
Spillway design flood runoff, inches	22.56

OUTFLOW (Elev 693.2):

Total routed peak outflow, cfs	680,000
Spillway	673,500
Outlet works	6,500

OUTLET WORKS:
Type: 1 gated conduit
Dimension: 12' diameter
Invert Elevation: 515.0
Control: 2 - 5'8"x12' hydraulically operated slide gates
Release Versatility: Control down to approx. 10-20 c.f.s.

Feature	Elev Feet (msl)	Reservoir Area (acres)	Reservoir Capacity Accumulative (ac-ft)	Runoff (inches)	Incremental (ac-ft)	Spillway Capacity (cfs)	Outlet Works Capacity (cfs)
Top of Dam	698.0						
Maximum Design Water Surface	693.2	16,370	1,013,300	14.42		673,500	6,500
Top of Flood Control Pool & Spillway Crest	666.0	11,830	630,400	8.97	390,600	0	7,200
Top of Conservation Pool (Ultimate)	622.0	6,430	235,700	3.35	204,900		6,100
Top of Conservation Pool (Interim)	610.0	4,990	167,100	2.38		0	5,700
Sediment Reserve					34,900*		
Total Storage					630,400		
Maximum Tailwater	576.9						
Streambed	498.0						

* Sediment distributed as follows: 30,800 ac-ft below elev 622.0
4,100 ac-ft between elev 622.0 and 666.0

(IN OPERATION)

STILLHOUSE HOLLOW LAKE

(May 1977)

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: The impoundment tends to play a significant role in reducing the turbidity and suspended sediments associated with storm water runoff. The long-term effect of the impoundment is to act as a detention basin, tending to smooth out sharp variations in chemical quality in the Lampases River waters. The limited sampling conducted at the lake indicates that the quality of the water is generally good.

(b) Quantity: The impoundment tends to moderate the daily flow volumes passing the damsite by reducing the high flows. Planned operation of the project insures a more uniform streamflow during flood periods than would exist under natural conditions. The project has greatly increased the water available for beneficial uses such as water supply, recreation, and lake fishing.

(2) Negative effects: Thermal stratification of the lake waters begins to develop in early to late April and continues until September or October. The thermal stratification results in seasonal and areal variations in the concentrations of dissolved oxygen, dissolved metals, and pH. The thermal stratification and the subsequent depletion of oxygen in the hypolimnion produces an anaerobic environment near the bottom of the lake during the summer months. Consequently, water below about a 30 to 35 foot depth usually can not sustain fish life for any extended period. During this period the dissolved metals concentrations can be expected to increase near the bottom of the lake. The data also indicates that the impounded water has a slightly higher pH then the inflow waters. The project beach and recreational areas are monitored for pollution. Testing during periods of high use indicate occasionally high coliform counts. Algal growth is not a nuisance problem but is occasionally evidenced.

(3) Causes of negative effects: The thermal stratification pattern of the impounded waters is the main cause of any variation in the quality of the water in Stillhouse Hollow Lake. As the stratification increases and the dissolved oxygen decreases at the bottom of the lake the dissolved metals, such as iron and manganese can be expected to increase. The occasionally poor quality inflow waters also has some effect on the quality of the impounded water.

b. Project Effects on Instream Flows:

(1) General: Monthly flow volume frequency and duration curves for flows immediately downstream of the project under pre- and post-impoundment conditions are shown on Plates 1 through 24. It should be noted that the periods of record are different.

(2) Positive effects: The Stillhouse Hollow Dam project generally tends to smooth the flood waters of the Lampasas River passing the damsite and tends to reduce the downstream flood damages. The project tends to smooth the variance of the water quality constituent concentrations. The occasionally high fecal coliform counts and high chloride and sulfate concentrations experienced in the Lampasas River above the project are seldom experienced below the project. The limited data available on the quality of the water below the project indicates that the Texas Water Quality Standards are usually satisfied.

(3) Negative effects:

(a) Quality: The available data indicates that any impacts of the project that are detrimental to the downstream quality of water are seasonal and of short duration. Occasional hydrogen sulfide odors can be expected with releases made during the summer. Increased dissolved metals such as iron and manganese concentrations can also be expected when the hypolimnion waters have become depleted of dissolved oxygen.

(b) Quantity: A preliminary best-estimate by the Corps of Engineers of instream flow needs on a monthly basis for Stillhouse Hollow Dam was computed using pre- and post-impoundment period of record flows. Since the two periods of record differ they should be analyzed to determine natural climatic variations and the preliminary estimates adjusted appropriately. The following represents a composite instream maintenance flow based on pre-impoundment average and pre-impoundment median low flows as determined through the Montana Method and the Modified Tennant's Method respectively.

Month	Flow, c.f.s.	Month	Flow, c.f.s.
JAN	20	JUL	20
FEB	40	AUG	10
MAR	50	SEP	15
APR	50	OCT	15
MAY	100	NOV	15
JUN	50	DEC	20

Since impoundment of Stillhouse Hollow Lake the number of days of zero flow passing the damsite has generally increased, especially during the summer months. This deterioration of low-flows is detrimental to the instream maintenance flow needs downstream of the project.

(4) Cause of negative effects: Any degradation in the quality of the water directly below Stillhouse Hollow Dam can be attributed to the presence of the project, the subsequent thermal stratification of the impounded waters, and the lack of a multiple level low-flow release facility at the project. Since the conservation storage waters can only be released from one level the quality of the releases can not be controlled. The State of Texas claims the rights to the waters within its boundaries and requires a using agency to obtain a permit to use the water. Historically the State of Texas has not required the Brazos River Authority to make a guaranteed minimum release from Stillhouse Hollow Dam. Since conservation releases are made upon request by Brazos River Authority and no minimum releases are required the number of zero flow days has increased since impoundment.

c. Project Effect on System Regulation: Stillhouse Hollow Dam is an integral part of a system of projects for controlling flooding in the Brazos River Basin and for controlling surface water runoff for beneficial uses. Stillhouse Hollow Dam must be operated in conjunction with Proctor and Belton Dams to control flooding and reduce damages along the Little River. Improper operation has the potential of causing adverse effects in the form of unwarranted flood damages and fish kills, reduction of water for water supply and recreational benefits, and degradation of the quality of downstream waters.

6. Constraints on Obtaining Instream Quantity and Quality Objectives: The State of Texas claims the rights to the waters within its boundaries and requires a using agency to obtain a permit to use the water. Historically the State has not required the Brazos River Authority to make a guaranteed minimum release from Stillhouse Dam. The conservation releases are made only upon the request at the Brazos River Authority who has contracted for 100 percent of the available water supply storage. Since impoundment the number of days of zero flow passing the dam into the downstream channel has increased. The lack of a multiple-level low-flow outlet works means that low-flow releases will have to be made from the poorer quality hypolimnion waters. The project releases can only be controlled down to a minimum of about 10 to 20 c.f.s. and higher rates of release can only be controlled to plus or minus 10 c.f.s.

7. Alternatives:

a. Reservoir Regulation: The Fort Worth District has conducted three meetings with the U.S. Fish and Wildlife Service in connection with flow maintenance downstream of the Fort Worth District projects. It was agreed that the Fort Worth District would study Stillhouse Hollow Lake and seven other projects in greater detail. The study will include the feasibility of changing the regulation plan. See paragraph 9.

b. Structural Modification: See paragraph 9.

c. Storage Reallocation: See paragraph 9. A change in the storage allocations would have to be specifically authorized by amendment by the Congress.

8. Actions Taken to Date: The Fort Worth District has conducted three meetings with the U.S. Fish and Wildlife Service in connection with flow maintenance downstream of the Fort Worth District's projects. A detailed study on Stillhouse Hollow Lake and Dam has been agreed upon and the study will be coordinated with the U.S. Fish and Wildlife Service. The Corps of Engineers has made a preliminary best-estimate of the instream maintenance flow needs below the project. These and the findings of the study will be coordinated with the U.S. Fish and Wildlife Service.

9. Planned Actions: A detailed study of the Stillhouse Hollow Dam and Lake project will be conducted with emphasis on flow maintenance downstream of the project. The project is one of eight projects for which detailed studies were agreed upon. The eight projects will be studied in downstream order with Stillhouse Hollow being the eighth project studied. The hydrologic and biologic analyses will be performed and operational and structural alternatives investigated for possible improvement in low flow releases. The increase in the number of days of zero flow passing into the downstream channel is the major area of concern with regards to satisfying instream maintenance flow needs. Preliminary study indicates that, with the constraints described in paragraph 6, either a change in the plan of regulation for low-flows or a reallocation of storage would be the most feasible solution. The alternatives evaluated will necessarily take such factors as legal feasibility, downstream and lake fishery, water quality, aesthetics, flood control, water supply, recreation, and periodic shutdowns for maintenance into account. A rough estimate of the cost to complete the studies, including additional hydrologic analyses, environmental analyses, coordination with other agencies, contract negotiations, etc. is $55,000. Schedule for completion of the studies will be dependent on manpower and funds availability. Objectives have been stated previously in this report.

GEORGETOWN LAKE, TEXAS

1. Project Name: North Fork Dam and Georgetown Lake

2. Project Location: River mile 4.3 on North Fork at the San Gabriel River, Brazos River Basin. The project watershed (246 square miles) is located in the State of Texas.

3. Type of Project:

a. General Category: Multi-purpose storage lake (excluding hydropower).

b. Storage Allocations and Other Pertinent Data: See Exhibit 1. The total storage below the top of conservation pool, elevation 791.0 feet n.g.v.d., is approximately 37,100 acre-feet. Of this approximately 7,900 acre-feet is allocated for sediment accumulation and approximately 29,200 acre-feet is allocated for water supply. See paragraph 4b for discussion of contracts for water supply.

c. Hydropower Category: N/A

4. Water Management Criteria:

a. Authorized Project Purposes: Flood control, water supply, fish and wildlife, and recreation.

b. Water Use Contracts: The Brazos River Authority is contracting for 29,200 acre-feet, or 100 percent, of the available water supply storage below the top of conservation pool.

c. Interagency Agreements: None.

d. Informal Commitments: None.

e. Systems Regulation Objectives: The Brazos River Basin contains eight operational Corps of Engineers projects: Whitney, Waco, Proctor, Belton, Stillhouse Hollow, North Fork, Granger, and Somerville Dams. The operation of these projects is coordinated for the purpose of controlling floods within the Brazos River Basin. The projects each contain water supply storage space and the releases from this storage are coordinated with the appropriate using agency.

LOCATION: R.M. 4.3 on the North Fork of the San Gabriel River, Brazos River Basin, 3.5 miles west of Georgetown, Texas

DRAINAGE AREA:
246 square miles
One inch of runoff 13,120 ac-ft

DAM:

Type:	Rock fill, impervious core
Length	6,700' (including spillway)
Maximum Height:	164'
Top Width:	40'

SPILLWAY:

Crest Elev:	834.0
Length:	750'
Type:	Broadcrested (ungated)

INFLOW:

Spillway design flood peak, cfs	395,800
Spillway design flood volume, ac-ft	336,800
Spillway design flood runoff, inches	25.67

OUTLET WORKS: LOW-FLOW
Dimensions: 4 - 3'x4' intakes to wet well (empty into F. C. conduit)
Invert Elev: 1 each @ 738.5, 751.33, 764.17,777.0
Release Versatility: Control down to approx. 5 c.f.s.

OUTLET WORKS:
Type: One gated conduit
Dimension: 11-foot diameter
Invert Elev: 720.0
Control: 2 5'x11' hydraulically operation slide gates

Feature	Elev Feet (msl)	Reservoir Area (acres)	Reservoir Capacity Accumulative (ac-ft)	Runoff (inches)	Incremental (ac-ft)	Low-Flow Capacity (cfs)	Outlet Works Capacity (cfs)
Top of Dam	861.0	5,570					
Maximum Design Water Surface	856.0	5,070	220,100	16,78		265,800	4,700
Top of Flood Control Pool (Spillway Crest)	834.0	3,220	130,800	9.97	87,600		4,900
Top of Conservation Pool	791.0	1,310	37,100	2.83	29,200		3,900
Maximum Tailwater	750.4						
Sediment Reserve					14,000*		
Total Storage					130,800		
Streambed	699.0						

* Sediment distributed as follows: 7,900 ac-ft below elev 791.0
6,100 ac-ft between elev 791.0 and 834.0

GEORGETOWN LAKE

(May 1977)

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: The impoundment of water behind North Fork Dam should tend to reduce the turbidity associated with the storm runoff waters of the San Gabriel River. The dam will also act as a sediment retarding structure reducing the downstream sediment load. Available data indicates that the quality of the water impounded should generally be within the recommended standards after initial impoundment conditions stabilize. The project should provide a good environment for the enhancement of and propagation of a lake fishery. The actual effects are unknown since the impoundment has been operational for less than a year.

(b) Quantity: The impoundment was designed to smooth out the sharp peaked flood flows of the San Gabriel River. The project has been operational for less than one year but will increase the quantity of water available for beneficial uses such as water supply, lake recreation, and lake fishing.

(2) Negative effects: It is anticipated that initially there will be an increase in the nutrient concentrations, the color, and biochemical oxygen demand. It is also anticipated that the dissolved oxygen, especially near the bottom, will be depressed. The initial deterioration in the quality of the water should reverse in 2 to 5 years and the quality and conditions should improve.

(3) Cause of negative effects: The initial short-term negative effects will be attributable to the leaching of the mineral and organic constituents of the soils and the decomposition of the vegetative ground cover.

b. Project Effects on Instream Flows:

(1) General: Monthly discharge frequency and duration for flows immediately downstream of the project for pre- and post-impoundment conditions are not presented since the project has been in operation for less than one year and post-impoundment data is not available.

(2) Positive effects: The project should smooth out the sharp peaked flood flows of the San Gabriel River and reduce the downstream

damages that would occur without the project. A preliminary best-estimate by the Corps of Engineers of instream flow needs on a monthly basis for North Fork Dam was computed using pre- and post-impoundment period of record flows. Since the two periods of record differ they should be analyzed to determine natural climatic variations and the preliminary estimates adjusted appropriately. The following represents a composite instream maintenance flow based on pre-impoundment average and pre-impoundment median low flows as determined through the Montana Method and the Modified Tennant's Method respectively.

Month	Flow, c.f.s.	Month	Flow, c.f.s.
JAN	10	JUL	10
FEB	10	AUG	5
MAR	15	SEP	5
APR	30	OCT	10
MAY	30	NOV	10
JUN	15	DEC	10

The Brazos River Authority will be responsible for the releases from the water supply storage after filling. The release request rates will determine if below project instream flow needs will be satisfied. The project will be using a release temperature guide curve to insure that releases to the downstream channel are of the best quality possible. During filling the Corps of Engineers will keep a live stream increasing the number of days of zero flow.

c. Project Effects on System Regulation: The projects within the Brazos River Basin are operated for flood control, water supply, and recreation. The North Fork Dam in conjunction with Granger Dam are responsible for controlling floods of the San Gabriel River. If the operation of these projects are not coordinated with the other Federal and non-Federal projects of the Brazos River Basin excess flood damages may occur, water supply storage may be depleted, the quality of the water degraded, the intake and downstream fisheries impacted.

6. Constraints on Obtaining Instream Quality and Quantity Objectives: The State of Texas claims the rights to the waters within its boundaries and requires a using agency to obtain a permit to use the water. The State of Texas has not required the Brazos River Authority to make a guaranteed minimum downstream release from North Fork Dam. Since the

Brazos River Authority is contracting for 100 percent of the conservation storage and will be pumping water from the lake for water supply the releases through the project will be limited to flood-control storage releases. The releases can only be controlled down to about 5 c.f.s. and higher rates controlled to plus or minus 5 c.f.s.

7. Alternatives:

a. Reservoir Regulation: None planned.

b. Structural Modification: None planned.

c. Storage Reallocation: None planned.

8. Actions Taken to Date: The Fort Worth District has conducted three meetings with the U.S. Fish and Wildlife Service in connection with flow maintenance downstream of the Fort Worth District projects. Further study on the conditions at North Fork Dam is not planned.

9. Planned Actions: None.

GRANGER LAKE, TEXAS

1. Project Name: Granger Lake

2. Project Location: River mile 31.9 on San Gabriel River, Brazos River Basin. Project watershed (463 square miles) is located in the State of Texas and the downstream water management control stations are located in Texas.

3. Type of Project:

a. General Category: Multiple-purpose storage project (excluding hydropower).

b. Storage Allocations and Other Pertinent Data: See Exhibit 1. The total storage below the top of conservation pool, elevation 504.0 feet n.g.v.d., is approximately 65,500 acre-feet. Of this approximately 27,600 acre-feet is allocated for sediment accumulation and approximately 37,900 acre-feet is allocated for water supply storage. See paragraph 4b for water supply use contracts.

c. Hydropower Category: N/A

4. Water Management Criteria:

a. Authorized Project Purposes: Flood control, water supply, fish and wildlife, and recreation.

b. Water Use Contracts: The Brazos River Authority has contracted for approximately 37,900 acre-feet, or 100 percent, of the available water supply storage. Releases from the water supply storage will be the responsibility of the Brazos River Authority after the project has filled.

c. Interagency Agreements: None.

d. Informal Commitments: None.

e. Systems Regulation Objectives: The Brazos River Basin contains eight operational Corps of Engineers projects: Whitney, Waco, Proctor, Belton, Stillhouse Hollow, North Fork, Granger, and Somerville. The operation of these projects is coordinated for the purpose of controlling floods within the Brazos River Basin. The projects each contain water supply storage space and the releases from this storage are coordinated with the appropriate using agency.

PERTINENT DATA - GRANGER LAKE

LOCATION: R.M. 31.9 on San Gabriel River, Brazos River Basin, about 10 miles northeast of Taylor, Texas

DRAINAGE AREA:
709 square miles, 463 square miles (incremental)
One inch of runoff 37,813 ac-ft
One inch of runoff (incremental) 24,693 ac-ft

DAM:
Type: Rolled earth fill
Length: 16,320' (including spillway)
Maximum Height: 115'
Top Width: 30'

SPILLWAY:
Crest Elev: 528.0
Length: 950'
Type: Ungated ogee

INFLOW:
Spillway design flood peak, c.f.s. 521,000
Spillway design flood volume, ac-ft 903,800
Spillway design flood runoff, inches 23,900

OUTFLOW:
Total routed peak outflow, c.f.s. 342,330
Spillway 342,330
Outlet Works 0

OUTLET WORKS
Type: 1 gated conduit
Dimension: 18-foot diameter
Invert Elevation: 457.0
Control: 2-8.0'x18' hydraulically operated slide gates

LOW-FLOW OUTLETS (EMPTYING INTO FLOOD CONTROL CONDUIT:
Release versatility: Control down to approximately 5 c.f.s.
Intake Dimensions: 3'x4'
Number: 4
Control: 1-3'x4' manually operated slide gate at each intake to wet well

1-2'x4' manually operated gate in wet well with invert elevation 486.0

Invert Elev: 1 each @ 486.0, 492.0, 498.0, 504.0

Feature	Elev Feet (msl)	Reservoir Area (acres)	Reservoir Capacity: Accumulative (ac-ft)	Runoff (inches) (2)	Incremental (ac-ft)	Low-Flow Capacity (cfs)	Outlet Works Capacity (cfs)
Top of Dam	555.0	21,000					
Maximum Design Water Surface	550.3	19,220	579,900	23.48			
Top of Flood-Control Pool (Spillway Crest)	528.0	11,040	244,200	9.89	162,200	370	11,700
Top of Conservation Pool	504.0	4,400	65,500	2.65	37,900	200	9,100
Maximum Tailwater	481.5						
Sediment Reserve					44,100(3)		
Total Storage					244,200		
Streambed	440.0						

(2) Based on a drainage area of 463 square miles.
(3) S[illegible]nt distributed as follows: 27,600 ac-ft bel[illegible] lev 504.0
16,500 ac-ft bet[illegible] elev 504.0 and 528.0

Exhibit 1 00467

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: The impoundment of water behind Granger Dam should tend to reduce the turbidity associated with the storm runoff waters of the San Gabriel River. The dam will also act as a sediment retarding structure reducing the downstream sediment load. Available data indicates that the quality of the water impounded should generally be within the recommended standards after initial impoundment conditions stabilize. The project should provide a good environment for the enhancement of and propagation of a lake fishery. The actual effects are unknown since the impoundment has been operational for less than a year.

(b) Quantity: The impoundment was designed to smooth out the sharp peaked flood flows of the San Gabriel River. The project has been operational for less than one year but will increase the quantity of water available for beneficial uses, such as water supply, lake recreation, and lake fishing.

(2) Negative effects: It is anticipated that initially there will be an increase in the nutrient concentrations, the color, and biochemical oxygen demand. It is also anticipated that the dissolved oxygen, especially near the bottom, will be depressed. The initial deterioration in the quality of the water should reverse in 2 to 5 years and the quality and conditions should improve.

(3) Cause of negative effects: The initial short-term negative effects will be attributable to the leaching of the mineral and organic constituents of the soils and the decomposition of the vegetative ground cover.

b. Project Effects on Instream Flows:

(1) General: Monthly discharge frequency and duration curves for flow immediately downstream of the project for pre- and post-impoundment conditons are not presented since the project has been in operation for less than one year, and post-impoundment data is not available.

(2) Positive effects: The project should smooth out the sharp peaked flood flows of the San Gabriel River and reduce the downstream damages that would occur without the project. A preliminary best-estimate by the Corps of Engineers of instream flow needs on a monthly basis for Granger Dam was computed using pre- and post-impoundment period of record flows. Since the two periods of record differ they should be analyzed to determine natural climatic variations and the preliminary estimates adjusted appropriately. The following represents a composite instream maintenance flow based on pre-impoundment average and pre-impoundment median low flows as determined through the Montana Method and the Modified Tennant's Method respectively.

Month	Flow, c.f.s.	Month	Flow, c.f.s.
JAN	25	JUL	10
FEB	30	AUG	10
MAR	30	SEP	10
APR	50	OCT	20
MAY	50	NOV	20
JUN	30	DEC	20

The Brazos River Authority will be responsible for the releases from the water supply storage after filling. The release request rates will determine if below project instream flow needs are satisfied. The project will be operated using a release temperature guide curve to insure that releases to the downstream channel are of the best possible quality.

(3) Negative effects: It is anticipated that the project will increase the number of days of zero flow passing the damsite slightly, especially during the summer months. The Brazos River Authority will be responsible for the releases from the water supply storage after filling. During filling the Corps of Engineers will keep a live stream.

(4) Cause of negative effects: The Brazos River Authority has contracted for 100 percent of conservation storage. The Brazos River Authority will pump from the impoundment rather than making releases through the outlet works, thus increasing the number of days of zero flow.

c. Project Effects on System Regulation: The projects within the Brazos River Basin are operated for flood control, water supply, and recreation. The Granger Dam in conjunction with North Fork Dam are responsible for controlling floods of the San Gabriel River. If the

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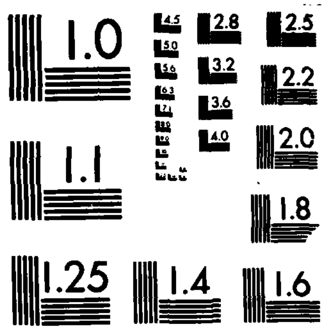

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operation of these projects are not coordinated with the other Federal and non-Federal projects of the Brazos River Basin excess flood damages may occur, water supply storage may be depleted, the quality of the water degraded, and the intake and downstream fisheries impacted.

6. Constraints on Obtaining Instream Quality and Quantity Objectives: The State of Texas claims the rights to the waters within its boundaries and requires a using agency to obtain a permit to use the water. The State of Texas has not required the Brazos River Authority to make a guaranteed minimum downstream release from Granger Dam. Since the Brazos River Authority has contracted for 100 percent of the conservation storage and will be pumping water from the lake for water supply the releases through the project will be limited to flood-control storage releases. The releases can only be controlled down to about 5 c.f.s. and higher release rates controlled to plus or minus 5 c.f.s.

7. Alternatives:

a. Reservoir Regulation: None planned.

b. Structural Modification: None planned.

c. Storage Reallocation: None planned.

8. Actions Taken to Date: The Fort Worth District has conducted three meetings with the U. S. Fish and Wildlife Service in connection with flow maintenance downstream of the Fort Worth District projects. Further study on the conditions at Granger Dam is not planned.

9. Planned Actions: None.

SOMERVILLE LAKE, TEXAS

1. Project Name: Somerville Lake

2. Project Location: River mile 20.0 on Yequa Creek, Brazos River Basin. The project watershed (1,006 square miles) is located in the State of Texas and the downstream water management stations are located in Texas.

3. Type of Project:

a. General Category: Multi-purpose storage lake (excluding hydropower).

b. Storage Allocations and Other Pertinent Data: See Exhibit 1. The total storage below the top of conservation pool, elevation 238.0 feet n.g.v.d., is approximately 160,100 acre-feet. Of this, approximately 16,200 acre-feet is allocated for sediment accumulation and approximately 143,900 acre-feet is allocated for water supply. See paragraph 4b for discussion of contracts for water supply.

c. Hydropower Category: N/A

4. Water Management Criteria:

a. Authorized Project Purposes: Flood control, water supply, and recreation by 711 program.

b. Water Use Contracts: The Brazos River Authority has contracted for 143,900 acre-feet, or 100 percent, of the available water supply storage below top of conservation pool, elevation 238.0 feet n.g.v.d. The regulation of the use of water in the contracted for storage space is the responsibility of the Brazos River Authority.

c. Interagency Agreements: None.

d. Informal Commitments: None.

e. System Regulation Objectives: Somerville Dam is located on the main stem of Yegua Creek 20.0 river miles upstream from the confluence of the Brazos River with Yegua Creek. The Somerville Lake is part of a system of projects for controlling the floodwaters on the Yegua Creek and Lower Brazos River watersheds. The Somerville Lake controls floodwaters on Lower Yegua Creek, Stillhouse Hollow Lake controls

LOCATION: R.M. 20.0 on Yegua Creek, Brazos River Basin, 2 miles south of Somerville, Texas

DRAINAGE AREA:
1,006 square miles
One inch of runoff - 53,653 acre-feet

DAM:
Type: Earth fill
Length: 20,210' (plus 4,715' dike)
Maximum Height: 80'
Top Width: 20' (dike 34')

SPILLWAY:
Crest Elev: 258.0
Length: 1,250' net at crest
Type: Ogee
Control: None

INFLOW:

Spillway design flood peak, cfs	415,700
Spillway design flood volume, ac-ft	1,374,800
Spillway design flood runoff, inches	25.62

OUTFLOW:

Total routed peak outflow, cfs	288,700
Spillway	286,000
Outlet Works	2,700

OUTLET WORKS:
Type: 1 gate controlled conduit
Dimension: 10' diameter
Invert Elevation: 206.0
Control: 2 - 5'x10' tractor type gates
Release versatility: Control down to about 10 to 20 c.f.s.

Feature	Elev Feet (msl)	Reservoir Area (acres)	Reservoir Capacity: Accumulative (ac-ft)	Reservoir Capacity: Runoff (inches)	Reservoir Capacity: Incremental (ac-ft)	Spillway Capacity (cfs)	Outlet Works Capacity (cfs)
Top of Dam	280.0						
Maximum Design Water Surface	274.5	39,800	1,028,800	19.18		286,000	2,700
Top of Flood Control Pool (Spillway Crest)	258.0	24,400	507,500	9.46	337,700	0	3,300
Top of Conservation Pool (Ultimate)	238.0	11,460	160,100	2.98	143,900		2,500
Top of Conservation Pool (Interim)	230.0	7,950	83,100	1.55		0	2,100
Maximum Tailwater	243.8						
Streambed	200.0						
Sediment Reserve					25,900*		
Total Storage					507,500		

* Sediment reserve distributed as follows: 16,200 ac-ft below elev 238.0
9,700 ac-ft between elev 238.0 and 258.0

(IN OPERATION)

SOMERVILLE LAKE

(May 1977)

Exhibit 1

00472

floods on the Lampasas River, Proctor Lake and Belton Lake controls floods on the Leon River, and the North Fork and Granger Lakes control floods on the San Gabriel River. These lakes together with Whitney Lake on the Brazos River, and Waco Lake on the Bosque River, form a system of lakes for controlling the area between the dams and north of the Brazos River. These projects are also operated to control the surface water runoff for other beneficial purposes such as water supply, recreation and hydroelectric power.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: Periodic testing of the Somerville Lake waters indicates that the quality of the water impounded is generally good, with the exception of bacteriological data. The project generally acts as a sediment retarding structure and tends to reduce the turbidity of storm runoff.

(b) Quantity: The project has greatly increased the quantity of water available for beneficial uses such as water supply, lake recreation, and lake fishing.

(2) Negative effects: The quality of the impounded water experiences seasonal variations in constituent concentrations. The impoundment is generally of good quality but during the summer months problems are experienced for short periods. Thermal stratification begins to develop in Somerville Lake in late March to early April and continues until September or October. The stratification results in a depletion of dissolved oxygen in the hypolimnion and by mid to late summer the dissolved oxygen concentration at the bottom of the lake is often zero. During this period that portion of the lake capable of sustaining fish life for an extended period is limited to the top 30 to 40 feet of depth. Periodic testing indicates that dissolved solids, sulfate, and chloride concentrations occasionally exceed recommended Texas Water Quality Standards. The data indicates that slightly elevated fecal coliform counts are observed in feeding areas of migratory waterfowl, at recreation and beach areas and at tributary inflow points. The project tends to concentrate in the hypolimnion, the sometimes high levels of dissolved solids, chlorides, and sulfates contained in the inflow waters.

(3) Cause of negative effects: The impoundment of water behind Somerville Dam and the subsequent thermal stratification of the stored water is the main cause of depletion of the dissolved oxygen in the hypolimnion waters during the summer. The impoundment is responsible for concentrating the levels of dissolved solids, chlorides, and sulfates contained in the inflow waters. The elevated levels of fecal coliforms during the summer months are apparently due to non-point source runoff and sewage treatment plant discharges in to the tributaries flowing into Somerville Lake, the seasonally large numbers of migratory waterfowl feeding at the lake, and the seasonally heavy use of recreation and beach areas.

b. Project Effects on Instream Flows:

(1) General: Monthly flow volume frequency and duration curves for flows immediately downstream of the Somerville Dam under pre-impoundment and post-impoundment conditions are shown on Plates 1 through 24. It should be noted that the periods of record were different and the climatic conditions were different.

(2) Positive effects: The Somerville Dam project generally tends to smooth the peak flood flows of Yegua Creek and tends to reduce downstream flood damages. The project has decreased the mean number of days of zero flow passing the damsite during the summer months but has slightly increased the mean number of days of zero flow passing the damsite during the winter months. The impoundment tends to reduce the turbidity and suspended sediments associated with storm runoff.

(3) Negative effects:

(a) Quality: Analysis of the quality of the water immediately below the dam indicates that several parameters are often outside the recommended Texas Water Quality Standards. The data indicates that there is a problem with respect to dissolved solids, chlorides, and sulfate concentrations. Of 155 test samples, 89 samples showed dissolved solids concentrations in excess of the recommended 250 mg/1, 64 samples showed chloride concentrations in excess of the recommended 75 mg/1, and 87 samples showed sulfate concentrations in excess of the recommended 75 mg/1. The dissolved solids of the samples ranged from 52 mg/1 to 1160 mg/1 with a mean of 359 mg/1 and a standard deviation of 203 mg/1. The chloride concentrations of the samples tested ranged from 4 mg/1 to 350 mg/1 with a mean concentration of 81 mg/1 and a standard deviation of 61 mg/1. The sulfate concentrations ranged from 4 mg/1 to 360 mg/1 with a mean concentration of 106 mg/1 and a standard deviation of 69 mg/1.

(b) Quantity: A preliminary best-estimate by the Corps of Engineers of instream flow needs on a monthly basis for Somerville Dam was computed using pre- and post-impoundment period of record flows. Since the two periods of record differ they should be analyzed to determine natural climatic variations and the preliminary estimates adjusted appropriately. The following represents a composite instream maintenance flow based on pre-impoundment average and pre-impoundment median low flows as determined through the Montana Method and the Modified Tennant's Method respectively.

Month	Flow, c.f.s.	Month	Flow, c.f.s.
JAN	40	JUL	10
FEB	40	AUG	5
MAR	40	SEP	5
APR	60	OCT	10
MAY	60	NOV	15
JUN	20	DEC	20

The project has generally tended to slightly increase the mean number of days of zero flow passing the damsite during the winter and spring months. This deterioration in low-flows is detrimental to the instream maintenance flow needs downstream of the the project.

c. Project Effect on System Regulation: The projects in the Brazos River Basin are operated for flood control, water conservation, hydropower generation, and for other beneficial uses of the surface water runoff. The storage of water is controlled at projects independently to satisfy conservation needs of each local area except in the the case of Whitney where power releases are partially dependent on releases made at the Brazos River Authority Possum Kingdom hydropower project. Flood control releases from all of the projects are made on a system basis to furnish flood protection to the basin as a whole. The improper operation of any project may cause detrimental effects to the immediate area below the project as well as to the basin as a system. Somerville Dam operations have the potential of adversely effecting the downstream flood protection and the quality of the downstream waters.

6. Constraints on Obtaining Instream Quality and Quantity Objectives: The project does not have a multiple-level low-flow release capability and all low-flows must be made from the poorer quality hypolimnion waters. This problem is added to by the slightly degraded quality of the inflow waters and the concentrating of chlorides and sulfates in the lower level of the lake waters. Control of low-flow release rates is restricted

since the flows can only be controlled down to a minimum of about 10 to 20 c.f.s. and since higher flows can only be controlled to plus or minus 10 c.f.s. The State of Texas claims the rights to the waters within its boundaries and requires a using agency to obtain a permit to use the water. Historically, the State of Texas has not required the Brazos River Authority to make a guaranteed maximum release from Somerville Dam. The regulation of the use of the contracted storage is the responsibility of the Brazos River Authority.

7. Alternatives:

a. Reservoir Regulation: The Fort Worth District has conducted three meetings with the U. S. Fish and Wildlife Service in connection with flow maintenance downstream of the Fort Worth District Projects. It was agreed that the Fort Worth District would study Somerville Lake and seven other projects in greater detail. The study will include the feasibility of changing the regulation plan. See paragraph 9.

b. Structural Modification: See paragraph 9.

c. Storage Reallocation: None proposed. A change in the storage allocations would have to be specifically authorized by amendment by the Congress.

8. Actions Taken to Date: The Fort Worth District has conducted three meetings with the U. S. Fish and Wildlife Service in connection with flow maintenance downstream of the Fort Worth District projects. A detailed study on Somerville Lake and Dam has been agreed upon and the study will be coordinated with the U. S. Fish and Wildlife Service.

9. Planned Actions: A detailed study of the project will be conducted with emphasis on flow maintenance downstream of the project. The project is one of eight projects for which detailed studies were agreed upon. The eight projects will be studied in downstream order with Somerville Lake being the second project studied. The hydrologic and biologic analyses will be performed and operational and structural alternatives investigated for possible improvement in low flow releases. The increase in the number of days of zero flow passing into the downstream channel is the major area of concern with regards to satisfying instream flow maintenance needs. Preliminary study indicates that since all of the available water supply storage is contracted for, either a change in the regulation plan or a storage reallocation is the most feasible approach to satisfying downstream needs. The constraints discussed in paragraph 6 will be considered in the final study. The alternatives

evaluated will necessarily take such factors as legal feasibility, downstream and lake fishery, water quality, aesthetics, flood control, water supply, recreation, and periodic shutdowns for maintenance into account. A rough estimate of the cost to complete the studies, including additional hydrologic analyses, environmental analyses, coordination with other agencies, contract negotiations, etc. is $50,000. Schedule for completion of the studies will be dependent on manpower and funds availability. Objectives have been stated previously in this report.

O. C. FISHER LAKE, TEXAS

1. Project Name: O. C. Fisher Lake

2. Project Location: River mile 6.6 on the North Concho River, Colorado River Basin. The project watershed (1,511 square miles) is located in the State of Texas and the downstream water management control stations are located in Texas.

3. Type of Project:

a. General Category: Multiple-purpose storage lake (excluding hydropower).

b. Storage Allocations and Other Pertinent Data: See Exhibit 1. The total storage below the top of conservation pool, elevation 1908.0 feet n.g.v.d., is approximately 119,200 acre-feet. Of this approximately 38,800 acre-feet is allocated for sediment accumulation and approximately 80,400 acre-feet is allocated for water supply. See paragraph 4b for water supply contracts.

c. Hydropower Category: N/A

4. Water Management Criteria:

a. Authorized Project Purposes: Flood control, water supply, and recreation under the 711 program.

b. Water Use Contracts: The Upper Colorado River Authority has contracted for approximately 80,400 acre-feet, or 100 percent of the storage available for water supply below top of conservation pool, elevation 1908.0 feet n.g.v.d.

c. Interagency Agreements: None.

d. Informal Commitments: None.

e. Systems Regulation Objectives: O. C. Fisher Dam is responsible for reducing flood flows of the Concho River and to a limited degree on the main stem of the Colorado River. The operation of the project must be coordinated with the other projects within the Colorado River Basin for effective flood control.

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

LOCATION: R.M. 6.6 on the North Concho River, Colorado River Basin near San Angelo, Tom Green County, Texas

DRAINAGE AREA:
1,511 square miles
One inch of runoff - 80,587 acre-feet

DAM:
Type: Rolled earth fill
Length: 40,885' (including spillway)
Maximum Height: 128'
Top Width: 20'

SPILLWAY:
Crest Elevation: 1,938.5
Length: 1,150'
Type: Ogee (ungated)

OUTLET WORKS:
Type: 2 conduits with 6 gated inlets
Dimensions:
Conduits: 2-18'
Inlets: 6-7.5'x14.5'
Invert Elevation: 1,840.0
Control: 6-7.5'x14.5' slide gates

LOW-FLOW OUTLETS:
Type: 2-30" steel pipes, paralleling flood control conduits
Invert Elevation: 1,878.5 (intake to wet well)
Release versatility: Control down to approximately 10 c.f.s.

Feature	Elev Feet (msl)	Reservoir Area (acres)	Reservoir Capacity: Accumulative (ac-ft)	Reservoir Capacity: Runoff (inches)	Reservoir Capacity: Incremental (ac-ft)	Spillway Capacity (cfs)	Outlet Works Capacity (cfs): 1 inlet	Outlet Works Capacity (cfs): 2 inlets	Outlet Works Capacity (cfs): 1 cond	Outlet Works Capacity (cfs): 2 cond	Low-Flow Outlets Capacity (cfs): 1 pipe	Low-Flow Outlets Capacity (cfs): 2 pipes
Top of dam	1964.0											
Maximum design water surface	1958.0	18,390	696,300	8.64		356,200					118.5	237
Top of flood control pool and spillway crest	1938.5	12,700	396,400	4.92	277,200	0	7,400	14,000	15,650	31,300	108.5	217
Top of conservation pool	1908.0	5,440	119,200	1.48	80,400		5,930	11,200	12,550	25,100	91	182
Invert, lowest intake	1840.0	3	5	0			0	0	0	0		
Streambed	1836.0	0	0									
Sediment reserve					38,800							
Total storage					396,400							

(IN OPERATION)

O. C. FISHER DAM AND LAKE

(May 1977)

(1) Positive effects:

(a) Quality: The limited available data indicates that the quality of the impounded waters is generally good. The project tends to reduce the turbidity of storm runoff flows and tends to act as a sediment retarding structure.

(b) Quantity: O. C. Fisher Dam tends to reduce the sharp peaked flood flows of the watershed and stores water for flood control and water supply purposes. The project has increased the quantity of water available for beneficial uses such as water supply, lake regulation, and lake fishing.

(2) Negative effects:

(a) Quality: The lake develops a very mild thermal stratification during the summer months with a temperature differential of about 5° to 10° F. During this period only the top 20 to 25 feet of depth has a dissolved oxygen concentration of 5.0 mg/l or greater, that required to sustain fish and invertibrate life.

(b) Quantity: The inflow volume has historically been small with extended periods of zero flow. The pool elevation has been below the lowest City of San Angelo water supply intake invert elevation for the last several years. During this period the only water passing into the downstream channel has been from gate leakage.

(c) Cause of negative effects: The thermal stratification pattern of the lake waters is the major cause of the dissolved oxygen depletion in the lower level of the lake. The extended period of reduced inflows is the cause of the low pool elevation.

b <u>Project Effects on Instream Flow:</u>

(1) General: Monthly flow volume frequency and duration curves for flows immediately below the project under pre- and post-impoundment conditions are shown on Plates 1 through 24. It should be noted that the periods of record for the two conditions are not the same.

(2) Positive effects: The quality of the downstream channel waters is not known and since the quality of the release flows is not monitored the effect of the project on instream quality is not known.

(3) Negative effects: The O. C. Fisher Lake project has increased the number of days of zero flow passing the damsite, especially during the summer months. This reduction in low-flow volume is detrimental to the instream flow maintenance needs below the project.

(4) Cause of negative effects: The construction of the project, the historically small inflow volume and the lack of a guaranteed minimum release are the main causes of the increase in zero flow days.

c. Project Effects on System Regulation: O. C. Fisher Dam is operated to control the flood waters and flood damages along the North Concho River, the Concho River and to a limited extent on the upper Colorado River. Flood releases must be coordinated with the operation of the other Federal and non-Federal dams in the system.

6. Constraints on Obtaining Instream Quality and Quantity Objectives: The historically small inflow volume and the lack of a guaranteed minimum release are major constraints in obtaining downstream flow maintenance objectives.

7. Alternatives:

a. Reservoir Regulation: None proposed.

b. Structural Modification: None proposed.

c. Storage Reallocation: None proposed.

8. Actions Taken to Date: The Fort Worth District has conducted three meetings with the U. S. Fish and Wildlife Service to discuss flow maintenance downstream of the Fort Worth District projects. Inasmuch as the U. S. Fish and Wildlife Service agreed with the Fort Worth District's assessment that conditions at the O. C. Fisher Dam project could not feasibly be improved, no additional study or actions for flow maintenance are planned.

9. Planned Actions: None proposed.

HORDS CREEK LAKE, TEXAS

1. Project Name: Hords Creek Lake

2. Project Location: River mile 27.8 on Hords Creek, Pecan Bayou Watershed, Colorado River Basin. The project watershed (48 square miles) is located in the State of Texas and the downstream water management control stations are located in Texas.

3. Type of Project:

a. General Category: Multiple-purpose storage lake (excluding hydropower).

b. Storage Allocations and Other Pertinent Data: See Exhibit 1. The total storage below the top of conservation pool, elevation 1,900.0 feet n.g.v.d., is approximately 8,640 acre-feet. Of this approximately 2,860 acre-feet of storage is allocated for sediment accumulation and approximately 5,780 acre-feet is allocated for water supply. See paragraph 4b for water supply use contracts.

c. Hydropower Category: N/A

4. Water Management Criteria:

a. Authorized Project Purposes: Flood control, water supply, and recreation.

b. Water Use Contracts: The Central Colorado River Authority has contracted for approximately 5,780 acre-feet, or 100 percent, of the available water supply storage with the City of Coleman subcontracting for the use of the water.

c. Interagency Agreements: None.

d. Informal Commitments: None.

e. Systems Regulation Objectives: Hords Creek Dam is operated to control the floods of Hords Creek and in conjunction with the Federal and non-Federal projects of the Colorado River to control the flood waters and to prevent flood damages in the Colorado River Basin. The conservation waters of Hords Creek Lake are controlled and used for water supply and recreational activities.

LOCATION: R.M. 27.8 on Hords Creek, Pecan Bayou Watershed, Colorado River Basin, 13 miles west of Coleman, Texas.

DRAINAGE AREA:
48 square miles
One inch of runoff - 2,560 acre-feet

DAM:
Type: Rolled earth fill
Length: 6,800' (incl spillway)
Maximum height: 91'
Top width: 24'

SPILLWAY:
Crest elev: 1,920.0
Length: 500'
Type: Broadcrested, ungated

OUTLET WORKS:
Type: 1 conduit with 1 uncontrolled inlet
Dimensions:
Conduit - 8'
Inlets - 4'x6'
Invert elev: 1,900.0 (uncontrolled)
1,856.0 (gated)
Control: 2-4'x6' slide gates

WATER SUPPLY OUTLET:
Type: 1-24" C.I. pipe
Invert elev: 1 each at 1,893.25, 1,886.25, and 1,876.5

Release versatility: Control down to approximately 5 c.f.s.

Feature	Elev Feet (msl)	Reservoir Area (acres)	Reservoir Capacity: Accumulative (ac-ft)	Reservoir Capacity: Runoff (inches)	Reservoir Capacity: Incremental (ac-ft)	Spillway Capacity (cfs)	Outlet Works Capacity (cfs): Uncontrolled	Outlet Works Capacity (cfs): Uncontrolled + 1 gated	Outlet Works Capacity (cfs): Uncontrolled + 2 gated
Top of dam	1939.0								
Maximum design water surface	1933.6	2,330	49,290	19.25		60,800	900	2,350	2,500
Top of flood control pool	1920.0	1,260	25,310	9.89	16,670	0	810	2,120	2,260
Top of conservation pool	1900.0	510	8,640	3.38	5,780		0	1,050	1,780
Streambed (original)	1848.0	0	0	0				0	0
Sediment reserve					2,860				
Total storage					25,310				

(IN OPERATION)

HORDS CREEK LAKE

(May 1977)

Exhibit 1

00483

5. Project Evaluation:

a. Effects of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: The Hords Creek Dam tends to act as a sediment retarding structure by reducing the sediment load of Hords Creek. The project also reduces the turbidity associated with storm runoff.

(b) Quantity: Since the watershed is small and the travel time short, the impoundment tends to reduce the sharp peaked flash type floods of short duration along Hords Creek. The impoundment has increased the quantity of water available for beneficial uses such as water supply, lake recreation, and lake fishing.

(2) Negative effects: The Hords Creek Lake waters contain concentrations of dissolved solids and chlorides in excess of the recommended Texas Water Quality Standards. These concentrations have been slowly increasing over the years. Thermal stratification of the lake waters begins to develop in early to late May and persists until September or October. The thermal stratification results in seasonal and areal variations in the concentrations of various chemical constituents. The creation of an oxygen deficit in the lower layers of the lake during the period of stratification is an usual occurrence. By mid-summer dissolved oxygen concentrations approach zero, levels too low to support a significant amount of aerobic decomposition or to support fish life. During the summer months that portion of the lake capable of supporting most fish and invertebrate life is reduced to the top 15-20 feet of the lake.

(3) Causes of negative effects: The thermal stratification pattern of the impounded waters is the main cause for the variance in the quality of the water in Hords Creek Lake. The high levels of chlorides and dissolved solids is believed to be related to the production of brine associated with the production of oil and gas in the northwest portion of the watershed.

b. Project Effects on Instream Flows:

(1) General: Monthly flow volume frequency and duration curves for flows immediately downstream of the project under pre- and post-impoundment conditions are shown on Plates 1 through 24. It should be noted that the periods of record for the two conditions are not the same.

(2) Positive effects: Hords Creek Dam generally tends to smooth the flood flows generated by the Hords Creek watershed and tends to reduce the downstream damages. The project reduces the turbidity of the storm runoff and reduces the sediment transported downstream. The quality of the water released is not known and thus its impact upon downstream conditions is unknown.

(3) Negative effects: The Hords Creek Dam project has increased the number of days of zero flow passing the project, especially during the summer months. This reduction in low-flow volume is detrimental to the instream flow maintenance needs below the project. The quality of the release waters is not monitored and thus its impact upon the downstream conditions is unknown.

(4) Cause of negative effects: Any degradation in the quality of the water directly below Hords Creek Dam can be attributed to the presence of the dam, the subsequent thermal stratification of the impounded waters, the lack of a multiple level release facility for downstream flows, and the degenerating quality of the inflow waters. The construction of the project, the historically small inflow volumes, the lack of a guaranteed minimum release, and the fact that water supply storage waters are pumped from the project have contributed to the increase in the number of days of zero flows passing the damsite.

c. Project Effects on System Regulations: Hords Creek Dam is operated to control the storm runoff of the Hords Creek watershed. In conjunction with the Federal and non-Federal projects of the Colorado River, Hords Creek Dam helps control flooding and flood damages along the Colorado River. Improper operation of the projects in the basin will adversely effect the quality of the water, the fish and wildlife habitats, and the agricultural and forest land along the river.

6. Constraints on Obtaining Instream Quality and Quantity Objectives:

a. Quality: The project lacks a multi-level withdrawal system for releasing flows into the downstream channel. Flows must be released through the service gate that draws from the zone of poorest quality water. The quality of the inflow waters is high on chlorides and dissolved solids and has an adverse effect on the quality of the impounded waters.

b. Quantity: The State of Texas claims the rights to the waters within its boundaries and requires a using agency to obtain a permit to use the water. Thus the releases into Hords Creek channel that may be required by the City of Coleman to provide for normal flow and to provide for downstream riparians is made only upon request by the City to the District Engineer, Fort Worth District. Releases can only be controlled down to a minimum of approximately 5 c.f.s. and higher release rates controlled to plus or minus 5 c.f.s.

7. Alternatives:

a. Reservoir Regulation: None proposed.

b. Structural Modification: None proposed.

c. Storage Reallocation: None proposed.

8. Actions Taken to Date: The Fort Worth District has conducted three meetings with the U.S. Fish and Wildlife Service to discuss flow maintenance downstream of the Fort Worth District projects. Inasmuch as the U.S. Fish and Wildlife Service agreed with the Fort Worth District assessment that conditions at the Hords Creek Dam project could not feasibly be improved, no additional study or actions for flow maintenance are planned.

9. Planned Actions: None proposed.

CANYON LAKE, TEXAS

1. Project Name: Canyon Lake

2. Project Location: River mile 303 on the Guadalupe River. The project watershed (1,432 square miles) is located in the State of Texas and the downstream water management control stations are located in Texas.

3. Type of Project:

a. General Category: Multiple-purpose storage lake (excluding hydropower).

b. Storage Allocations and Other Pertinent Data: See Exhibit 1. The total storage below the top of conservation pool, elevation 909.0 feet n.g.v.d., is approximately 386,200 acre-feet. Of this approximately 19,800 acre-feet is allocated for sediment accumulation and approximately 366,400 acre-feet is allocated for water supply. See paragraph 4b for water supply contracts.

c. Hydropower Category: N/A

4. Water Management Criteria:

a. Authorized Project Purposes: Flood control, water supply, recreation by 711 program, and the construction of hydroelectric power facilities at non-Federal expense.

b. Water Use Contracts: The Guadalupe - Blanco River Authority has contracted for approximately 366,400 acre-feet, or 100 percent of the storage available for water supply below top of conservation pool, elevation 909.0 n.g.v.d.

c. Interagency Agreements: None.

d. Informal Commitments: None.

e. Systems Regulation Objectives: Canyon Dam is operated to control and reduce downstream flooding and is governed by flood runoff from the watershed above the dam. Since the Guadalupe - Blanco River Authority has contracted for the conservation storage of Canyon Lake

LOCATION:
R.M. 303 on Guadalupe River and about 12 miles northwest of New Braunfels, TX, Comal County

DRAINAGE AREA:
1,432 square miles
One inch of runoff 76,000 acre-feet

DAM:
Type: Rolled earth fill w/spillway in saddle about 2,500' from rt abutment
Length: 6,830' (including dikes & spillway)
Maximum Height: 224'
Top Width: 20'
Dike: 10'

SPILLWAY:
Crest Elev: 943.0
Length: 1,260 feet net at crest
Type: Broadcrested
Control: None

INFLOW:

Spillway design flood peak, cfs	687,000
Spillway design flood volume, ac-ft	1,285,800
Spillway design flood runoff, inches	16.92

OUTFLOW (Elev 969.1):

Total routed peak outflow, cfs	508,000
Spillway	502,800
Outlet Works	5,200

OUTLET WORKS:
Type: 1 gate controlled conduit
Dimension: 10' diameter
Invert: 775.0
Control: 2-5'8"x10' hydraulically operated slide gates
Release Versatility: Controllable down to approx. 20-30 c.f.s.

Feature	Elev Feet (msl)	Reservoir Area (acres)	Reservoir Capacity: Accumulative (ac-ft)	Reservoir Capacity: Runoff (inches)	Reservoir Capacity: Incremental (ac-ft)	Spillway Capacity (cfs)	Outlet Works Capacity (cfs)
Top of Dam	974.0						
Maximum Design Water Surface	969.1	17,120	1,129,300	14.79		502,800	5,200
Top of Flood Control Pool	943.0	12,890	740,900	9.70	346,400		
Spillway Crest	943.0	12,890	740,900	9.70			
Top of Conservation Pool	909.0	8,240	386,200	5.06	366,400		4,670
Sediment Reserve					28,100*		
Total Storage					740,900		
Maximum Tailwater	813.9						
Streambed	750.0						

* Sediment distributed as follows: 19,800 ac-ft below elev 909.0
8,300 ac-ft between elev 909.0 and 943.0

(IN OPERATION)

(May 1977) CANYON LAKE

any low-flow releases for the purpose of satisfying riparian and appropriative rights, pollution abatement, and fish and wildlife requirements from the conservation storage will be the responsibility of the Guadalupe - Blanco River Authority.

5. Project Evaluation:

a. Effect of Impoundment on Water Stored:

(1) Positive effects:

(a) Quality: The impoundment of water behind Canyon Dam tends to reduce any turbidity associated with storm runoff waters and the dam acts as a sediment retarding structure. Available data indicates that the quality of the impounded waters is generally very good and that no significant salinity or salinity-induced stratification problems exist. Of 32 water samples test only two showed parameters outside of the recommended limits set by the Texas Water Quality Standards.

(b) Quantity: The impoundment tends to smooth out the flows in the Guadalupe River in the vicinity of the damsite and to reduce flood flows below the project. The project has greatly increased the quantity of water available for beneficial uses such as water supply, lake recreation, and lake fishing.

(2) Negative effects: Thermal stratification of the lake waters begins to develop in early to late March and persists until September or October. The thermal stratification results in seasonal and areal variations in dissolved oxygen, dissolved iron, and dissolved manganese. Oxygen utilized in the oxidation of dead organisms and other organic materials near the bottom of the lake produces an anaerobic environment in the lower level of the lake during the summer months. Consequently, water below about a 35 to 40 foot depth usually has less than 1.0 mg/l dissolved oxygen in early summer and usually reaches zero by middle to later summer in the deepest parts of the lake. The concentrations of dissolved iron and dissolved manganese in the surface waters is generally well within the recommended limits for drinking water established by the U.S. Public Health Service. During the months of greatest thermal stratification, however, the concentrations of dissolved iron and manganese can be expected to increase and possibly exceed the limits. Of the 32 water samples tested only two showed parameter concentrations outside the limits. The chloride concentration in two samples exceeded the recommended 80 mg/l. The maximum recorded was 200 mg/l.

(3) Causes of negative effects: The thermal stratification pattern of the impounded waters is the main cause of any variance in the quality of the water in Canyon Lake.

b. <u>Project Effects on Instream Flow</u>:

(1) General: Monthly flow volume frequency and duration curves for flows immediately downstream of the project under pre- and post-impoundment conditions are shown on Plates 1 through 24. It should be noted that the periods of record for the two conditions are not the same.

(2) Positive effects: The Canyon Dam project generally tends to smooth the flood waters of the Guadalupe River passing the damsite. The peak flood flows below the dam are reduced and the damages caused by flooding are reduced. The quality of the water below Canyon Dam is not monitored but based on the quality of the impounded waters it is expected that the quality of the release waters is generally good. The Guadalupe - Blanco River Authority has contracted for 100 percent of the conservation storage and by contract is responsible for and makes low-flow releases for the purpose of satisfying riparian rights, pollution abatement, and fish and wildlife requirements from the conservation storage.

(3) Negative effects: The low-head power facilities downstream of Canyon Dam operated by the Guadalupe - Blanco River Authority requires continuous manning when flows are in excess of 1,500 c.f.s. When the flows are in excess of 800 c.f.s. the conditions become unsafe for canoeing, a major recreational activity, below Canyon Dam. Releases are held below 800 c.f.s. when possible but are often in excess of 800 c.f.s. when flood control operations are in effect. The odor of hydrogen sulfide is occasionally associated with releases during the summer months. In the summer the release of impounded waters can also be expected to cause some deterioration of the quality of the downstream waters. The exact impact on the quality is unknown since the quality is not monitored.

(4) Cause of negative effects: Any degradation in the quality of the water directly below Canyon Dam can be attributed to the presence of the project, the subsequent thermal stratification of the impounded waters and summer anaerobic conditions at the bottom of the lake, and the lack of a multiple level low-flow release capability of the project. Since the project can release low-flows from only one level the quality of the release waters cannot be adequately controlled.

c. Project Effect on System Regulation: Canyon Dam is the only Corps of Engineers project on the Guadalupe River. It is responsible for flood control and for the control of the surface water runoff for other beneficial uses. The Guadalupe - Blanco River Authority operates several run-of-the-river low-head hydroelectric plants in the basin. The flows from Canyon Dam therefore have an impact on the operation of these projects as well as on the flood control and water conservation activities within the basin. Releases must therefore be coordinated to insure maximum benefits and minimal detrimental effects to instream flow needs. The conservation storage releases are made upon the request of the Guadalupe - Blanco River Authority. The releases can only be controlled down to about 20 to 30 c.f.s. minimum and higher rates controlled to plus or minus 10 c.f.s.

7. Alternatives:

a. Reservoir Regulation: None proposed.

b. Structural Modification: None proposed.

c. Storage Reallocation: None proposed.

8. Actions Taken to Date: The Guadalupe - Blanco River Authority has contracted for 100 percent of the conservation storage and any low-flow releases for the purpose of satisfying riparian and appropriative rights, pollution abatement, and fish and wildlife requirements from the conservation storage will be the responsibility of the Guadalupe - Blanco River Authority. The Fort Worth District has conducted three meetings with the U.S. Fish and Wildlife Service in connection with flow maintenance downstream of the Fort Wort District projects. Inasmuch as the U.S. Fish and Wildlife Service agrees with the Fort Wort District assessment that releases from Canyon Dam are satisfactory, no additional study for flow maintenance is planned.

9. Planned Actions: None proposed.

1. Project Name: ABIQUIU DAM

2. Project Location: Abiquiu dam is located at mile 33 on the Chama river, which is tributary to the Rio Grande. The Chama watershed above Abiquiu dam is 2,146 square miles in New Mexico and Colorado. Water management control stations are Chamita on the Rio Chama and Otowi Bridge on the Rio Grande in New Mexico.

3. Type of Project:

a. General category: single purpose.

b. Storage allocations:

	Elevation (Feet NGVD	Storage (Acre-Feet)	(Inches-runoff)
Flood Control	6072-6283.5	502,000	4.39
Sediment Space	--	63,000	.55

Water is stored in sediment space for City of Albuquerque.

c. Hydropower category: no power.

4. Water Management Criteria:

a. Authorized project purposes: flood control and sediment retention.

b. Water use contracts: City of Albuquerque.

c. Interagency agreements: none.

d. Informal commitments: State of New Mexico.

e. Systems regulation objectives: control flow in Rio Chama and Rio Grande to non-damage rates. Operate in compliance with the Rio Grande Compact.

5. Project Evaluation:

a. Effects of impoundment on water stored:

(1) Positive effects: Turbidity of water is reduced by temporary storage. Water storage acts as bacteriological filter and released water is practically free of coliform bacteria.

(2) Negative effects: Storage of flood waters contribute to algal blooms.

(3) Cause of negative effects: Nutrients are leached from the soil and turbidity is reduced thus creating more ideal conditions for algae growth.

b. Project effects on instream flows:

(1) General: Reduces flood peaks and increases duration of flow. Reduces turbidity and sediment movement. Total Rio Grande basin flow is appropriated and apportioned under New Mexico State law and the interstate compact between Colorado, New Mexico and Texas.

(2) Positive effects: Sediment load of outflows is reduced.

(3) Negative effects: None identified.

(4) Cause of negative effects:

c. Project effects on system regulation: Provides a high degree of flood protection on Rio Chama and Rio Grande.

6. Constraints on Obtaining Instream Quantity and Quality Objectives.

a. Quantity: All water appropriated under state law. Annual run-off insufficient to meet all needs.

b. Quality:

7. Alternatives.

a. Reservoir regulation: Presently have pool of transmountain water in sediment reserve space. It reduces turbidity and increases sediment retention.

b. Structural modification: Add two gates.

c. Storage reallocation: Space for storage of transmountain water.

8. Actions Taken to Date: None.

9. Planned Actions: None.

1. Project Name: COCHITI LAKE

2. Project Location: Cochiti dam is located at mile 1582 on the Rio Grande. The Rio Grande watershed above Cochiti dam is 11,695 square miles in Colorado and New Mexico. The water management station is located in Albuquerque, New Mexico.

3. Type of Project:

a. General category: multi-purpose.

b. Storage allocations:

	Elevation (Feet NGVD	Storage (Acre-feet)	(Inches-runoff)
Flood Control	5330-5460.5	480,000	0.77
Sediment Space		105,000	
Recreation	5321.45		0.07

Recreation pool is in the sediment space

c. Hydropower category: no power.

4. Water Management Criteria:

a. Authorized project purposes: Sediment retention, flood control and recreation.

b. Water use contracts: none.

c. Interagency agreements: none.

d. Informal commitments: none.

e. Systems regulation objectives: control high flow through the middle Rio Grande valley to minimize damage. Operate in compliance with the Rio Grande Compact.

5. Project Evaluation:

a. Effects of impoundment on water stored:

(1) Positive effects: Reduces flood peaks and increases duration of flows. Reduces turbidity. No storage with which to augment low flow.

(2) Negat've effects: Slight increase in water loss from increased evaporation. Stored flood waters contribute to nuisance algal blooms.

(3) Cause of negative effects: Stored waters leach nutrients from soil and turbidity is decreased, thus providing more ideal conditions for algae growth.

b. Project effects on instream flows:

(1) General: Operated for flood control. Reduces flood peaks and increases duration of flow. Normal operation is to pass inflow. Total Rio Grande flow is appropriated and apportioned under New Mexico State law and the interstate compact between Colorado, New Mexico and Texas.

(2) Positive effects: Reduces turbidity and sediment movement.

(3) Negative effects: None known.

(4) Cause of negative effects:

c. Project effects on system regulation: Provides a very high degree of flood protection to the middle Rio Grande Valley.

6. Constraints on Obtaining Instream Quantity and Quality Objectives:

a. Quantity: All water appropriated under state law. Annual volume of runoff is insufficient to meet all needs.

b. Quality:

7. Alternatives:

a. Reservoir regulation. None.

b. Structural modification. None.

c. Storage reallocation. None planned.

8. Actions Taken to Date: Study to determine feasibility of power plant addition.

9. Planned Actions: None.

1. Project Name: GALISTEO DAM

2. Project Location: The dam is on Galisteo Creek about 12 miles above the confluence with Rio Grande. The watershed above the dam is 596 square miles in New Mexico. The control station is in Albuquerque, New Mexico.

3. Type of Project:

a. General category: single purpose.

b. Storage allocations:

	Elevation (Feet NGVD	Storage (Acre-feet)	Storage (Inches-runoff)
Flood Control	5500-5608	79,600	2.50
Sediment Space		9,574	0.30

c. Hydropower category: No power.

4. Water Management Criteria:

a. Authorized project purposes: flood control and sediment retention.

b. Water use contracts: none.

c. Interagency agreements: none.

d. Informal commitments: none.

e. Systems regulation objectives: Project operation is automatic.

5. Project Evaluation:

a. Effects of impoundment on water stored:

(1) Positive effects: No permanent pool. Temporary storage to reduce flows to maximum of 5,000 cfs. Stream flow is intermittent. No flow most of time.

(2) Negative effects: None known.

(3) Cause of negative effects:

b. Project effects on instream flows:

(1) General: Minimal due to short detention time.

(2) Positive effects: Reduces turbidity and sediment movement.

(3) Negative effects: None known.

(4) Cause of negative effects:

c. Project effects on system regulation: Reduces flood peaks from Galisteo creek.

6. Constraints on Obtaining Instream Quantity and Quality Objectives.

a. Quantity: Intermittent stream. No flow most of the time. All water appropriated under state law.

b. Quality:

7. Alternatives.

a. Reservoir regulation: No change.

b. Structural modification: Add drop inlet structure so crest can be raised as sediment deposit builds up. Estimated cost 300 thousand dollars.

c. Storage reallocation: Not applicable.

8. Actions Taken to Date: Exploring cost of drop inlet structure.

9. Planned Actions: None.

1. Project Name: JEMEZ CANYON DAM

2. Project Location: The dam is 2 miles above the confluence with the Rio Grande. Jemez creek watershed is 1,034 square miles above the dam. The control station is in Albuquerque, New Mexico.

3. Type of Project:

a. General category: single purpose (dry reservoir).

b. Storage allocations:

	Elevation (Feet NGVD	Storage (Acre-feet)	Storage (Inches-runoff)
Flood Control	5160-5232	73,000	1.32
Sediment Space	--	63,000	1.14
Sediment Retention	5136-5160	2,000	0.04

Provided by the State of New Mexico from transmountain water.

4. Water Management Criteria:

a. Authorized project purpose: flood control-sediment retention.

b. Water use contracts: none.

c. Interagency agreements: none.

d. Informal commitments: none.

e. Systems regulation objectives: Control flow through the middle Rio Grande Valley to minimize damage. Operate in compliance with the Rio Grande Compact.

5. Project Evaluation:

a. Effects of impoundment on water stored:

(1) Positive effects: Sediment load is reduced and turbidity lessened.

(2) Negative effects: None known.

(3) Cause of negative effects:

b. Project effects on instream flows:

(1) General: Operated for flood control. Reduces flood peaks and increases duration of flow. Total Rio Grande basin flow is appropriated and apportioned under New Mexico State law and the interstate compact between Colorado, New Mexico and Texas.

(2) Positive effects: Reduces turbidity and sediment movement.

(3) Negative effects: None known.

(4) Cause of negative effects:

c. Project effects on system regulation: Provides a very high degree of flood protection to the middle Rio Grande Valley.

6. Constraints on Obtaining Instream Quantity and Quality Objectives.

a. Quantity: Intermittent stream. No flow much of time due to upstream irrigation diversions. All water appropriated under state law.

b. Quality:

7. Alternatives.

a. Reservoir regulation: Presently have 2,000 AF pool with water provided by Trans-mountain diversion. The sediment pool reduces turbidity and greatly increases sediment deposition.

b. Structural modification. A drop inlet structure could provide similar benefits to sediment pool. Cost of the structure was estimated at .5 million dollars.

c. Storage reallocation. None planned.

8. Actions Taken to Date: Established sediment pool.

9. Planned Actions: None.

1. Project Name: LOS ESTEROS LAKE

2. Project Location: Los Esteros Dam is at river mile 766.4 on the Pecos River. The Pecos river watershed above Los Esteros Dam is 2,434 square miles and all located in New Mexico. Downstream control points are Sumner Dam, Acme and Artesia, New Mexico.

3. Type of Project:

a. General category: multi-purpose.

b. Storage allocations:

	Elevation (Feet NGVD	Storage (Acre-feet)	Storage (Inches-runoff)
Flood Control	4776.5-4797	167,000	1.29
Water Supply	4630-4776.5	200,000	1.54
Sediment		82,000	0.63

c. Hydropower category: no power.

4. Water Management Criteria:

a. Authorized project purposes: flood control and water supply.

b. Water use contracts: WPRS irrigation.

c. Interagency agreements: WPRS.

d. Informal commitments: none.

e. Systems regulation objectives: Flood control operation is to balance storage and releases between Los Esteros and Sumner to maintain flood flow to 8,500 cfs below Sumner. Irrigation releases are in accordance with requests from WPRS Carlsbad Office. Operated in compliance with the Pecos River Compact.

5. Project Evaluation:

a. Effects of impoundment on water stored:

(1) Positive effects: Sediment load is reduced and turbidity is lessened.

(2) Negative effects: Impounded water may be degraded by gypsum leaching of the San Andres formation exposed in the canyon walls. Also, some leaching of asphalt may occur during extended periods of storage. The extent of degradation will not be known until there has been storage in the irrigation pool. The project began operation last year and it will probably be years before the extent of problems wil be known.

(3) Cause of negative effects: Underlying formations in reservoir contain gypsum and asphalt.

b. Project effects on instream flows:

(1) General: Reduces turbidity and sediment movement. Reduces peak flow and increases duration of flow. All stream flow appropriated and apportioned under New Mexico state law and interstate compact between New Mexico and Texas.

(2) Positive effects: Flood flow will be reduced in magnitude with longer duration of higher flow.

(3) Negative effects:

(4) Cause of negative effects:

c. Project effects on system regulation: Provides flood protection to main stem of Pecos by operation with Sumner to maintain downstream flood flow to maximum of 8,500 cfs. Primary flood control project.

6. Constraints on Obtaining Instream Quantity and Quality Objectives.

a. Quantity: All flow appropriated under state law.

b. Quality:

7. Alternatives.

a. Reservoir regulation. None planned.

b. Structural modification. None.

c. Storage reallocation. Not applicable.

8. Actions Taken to Date: None.

9. Planned Actions: None.

1. Project Name: TWO RIVERS DAM

2. Project Location: River mile 34 on the Rio Hondo which is tributary to Pecos river. The Rio Hondo watershed above the dams is 1,027 square miles and located in New Mexico. The control point is Roswell, New Mexico.

3. Type of Project:

a. General category: single-purpose.

b. Storage allocations:

	Elevation (Feet NGVD	Storage (Acre-feet)	Storage (Inches-runoff)
Flood Control	3957-4032	150,000	2.74
Sediment	--	18,000	.33

c. Hydropower category: No power.

4. Water Management Criteria:

a. Authorized project purpose: flood control.

b. Water use contracts: none.

c. Interagency agreements: none.

d. Informal commitments: none.

e. Systems regulation objectives: none. Operated to control flow in Rio Hondo at Roswell to channel capacity which is about 1,000 cfs.

5. Project Evaluation:

a. Effects of impoundment on water stored:

(1) Positive effects: Operated for flood control. Normally dry reservoir.

(2) Negative effects:

(3) Cause of negative effects:

b. Project effects on instream flows:

(1) General: Flow above channel capacity stored then released when downstream capacity becomes available. Reduces flood peaks and increases duration of flow. All flow appropriated under New Mexico state law. Pecos river flow apportioned under the interstate compact.

(2) Positive effects:

(3) Negative effects:

(4) Cause of negative effects:

c. Project effects on system regulation: Minimal. Flood flows in Pecos and Rio Hondo seldom coincide so that storage at Two Rivers is required.

6. Constraints on Obtaining Instream Quantity and Quality Objectives.

a. Quantity: Intermittent stream. No flow most of time. All water appropriated under state law.

b. Quality:

7. Alternatives.

a. Reservoir regulation. None.

b. Structural modification. Add drop inlet structure so crest can be raised as sediment deposit builds up. Estimated cost 400 thousand dollars.

c. Storage reallocation. Not applicable.

8. Actions Taken to Date. None.

9. Planned Actions: None.

Ozark Lake - Instream Flow Problems and Needs Evaluation

1. Project Name. Ozark Lake

2. Project Location: The Ozark-Jeta Taylor Lock and Dam is located on the Arkansas River at navigation mile 256.8. There are 151,801 square miles of drainage area above the lock and dam of which 22,241 square miles are probably noncontributing to runoff. There are no water management control stations downstream.

3. Type of Project.

a. General. Ozark-Jeta Taylor Lock and Dam is one of the major units in the McClellan-Kerr Arkansas River Navigation System for improvement of the Arkansas River and its tributaries in Arkansas and Oklahoma. The authorized project purposes are hydroelectric power generation, navigation, recreation, and fish and wildlife conservation.

b. Pertinent Data.

	Elevation ft. m.s.l.	Area Acres	Storage Capacity 1000 - ac-ft
Top of Power Pool	372.0	10,600	148.4
Top of Navigation Pool	370.0	8,800	129.0
Power Storage	372-370	-	19.4
Stream Bed	301.0	-	-

c. Outlets.

Type	No. & Size	Invert El ft. m.s.l.	Opening Size & Control	Max Discharge (cfs) Top Power	Top Navigation
Flat Crest Spillway	1-900'	327.0	15 - 50'x46' Tainter Gates	550,000	
Power Unit	5	299.8	-	70,000	

d. Power development.

Power Units

Main Generating Units, number		5
Rated Capacity, each unit,	KW	20,000
Total	KW	100,000

4. Water Management Criteria.

a. Authorized Project Purposes. Navigation, hydropower, recreation, and fish and wildlife conservation.

b. Water Use Contracts. None

c. Interagency Agreements. Southwestern Power Administration markets power.

d. Informal Commitments. None.

e. System Regulation Objectives. Many of the lakes upstream from Ozark Lake in the Arkansas River Basin have multiple purposes, which may include hydropower, irrigation, recreation, fish and wildlife conservation, water supply, navigation, flood control, and water quality. The locks and dams with navigation as a purpose are regulated to provide a minimum 9-foot depth in the navigation channel from Catoosa, Oklahoma, to the confluence with the White River. Ozark also reregulates flows within the 2 feet of power pondage provided for generation of hydropower.

5. Project Evaluation.

a. General. The period of retention of water in the impoundment is generally too short to cause any change in quality. The Arkansas Department of Pollution Control and Ecology monitors water quality along the waterway regularly and has not reported any deviation from water quality standards attributable to the impoundments or their operation. Noted problems have related to the operation of public (municipal) and private waste treatment facilities discharging into the waterway and to private industrial operations.

b. Effects of Impoundment on Water Stored. No significant effects are caused by this type of impoundment on the quality of the water.

c. Project Effects on Instream Flows. No significant effects are caused by this type of impoundment on the quality or quantity of flows. Annual discharge-duration curves for natural and existing (regulated) flows at the dam are shown in Figure 1, and annual peak and minimum discharge frequency curves are shown in Figures 2 through 5. These curves represent a computer simulation of mean daily flows for a period of record from October 1939 through September 1974.

d. Project Effects on System Regulation. The project provides for navigation on the Arkansas River, and pondage for hydroelectirc power generation.

6. Constraints on Obtaining Instream Quantity and Quality Objectives. None.

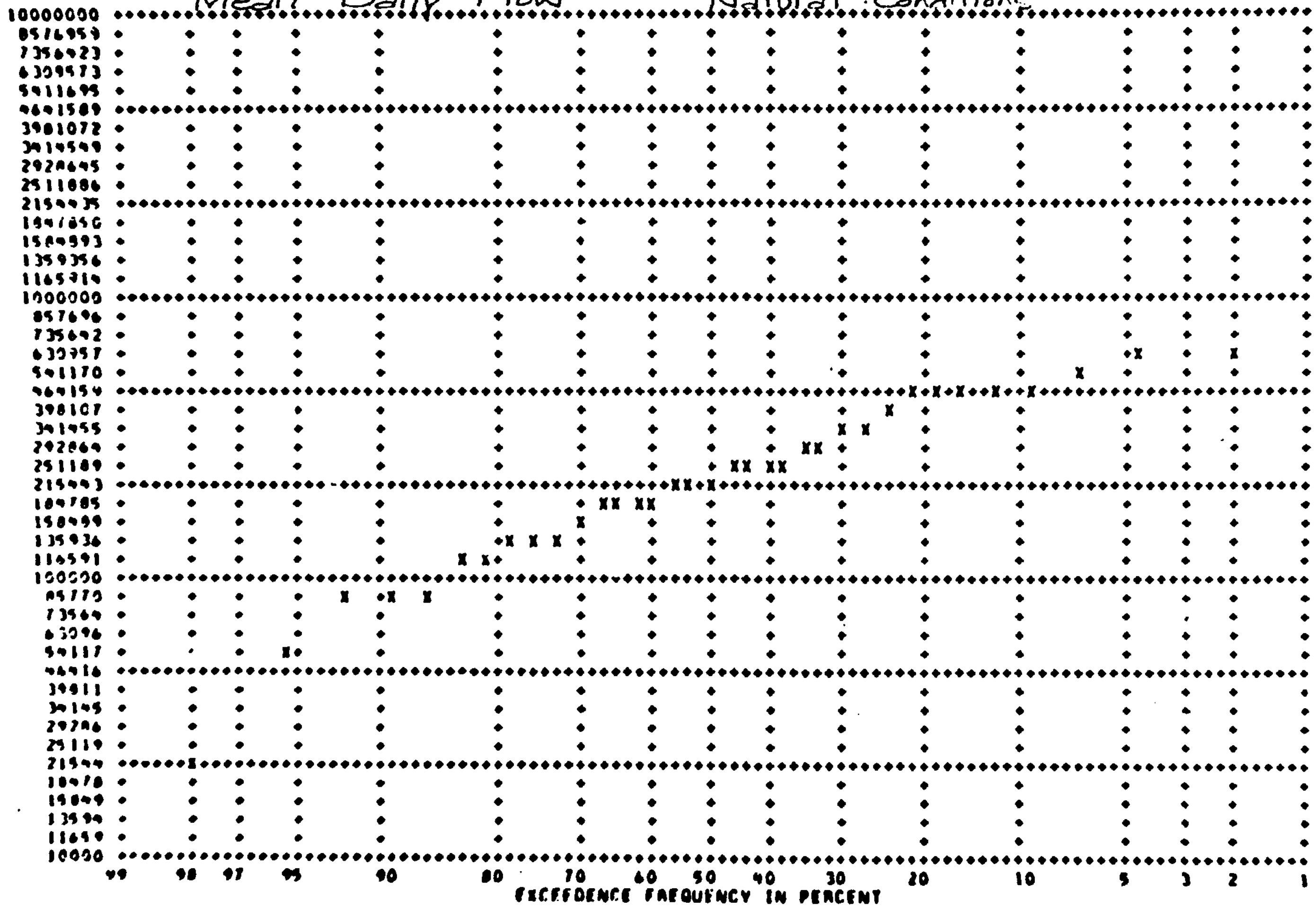
7. Alternatives. None.

8. Action Taken to Date. None.

9. Planned Actions. None.

OZARK OUTFLOW
ANNUAL PEAK DISCHARGE FREQUENCY

Mean Daily Flow Natural Conditions



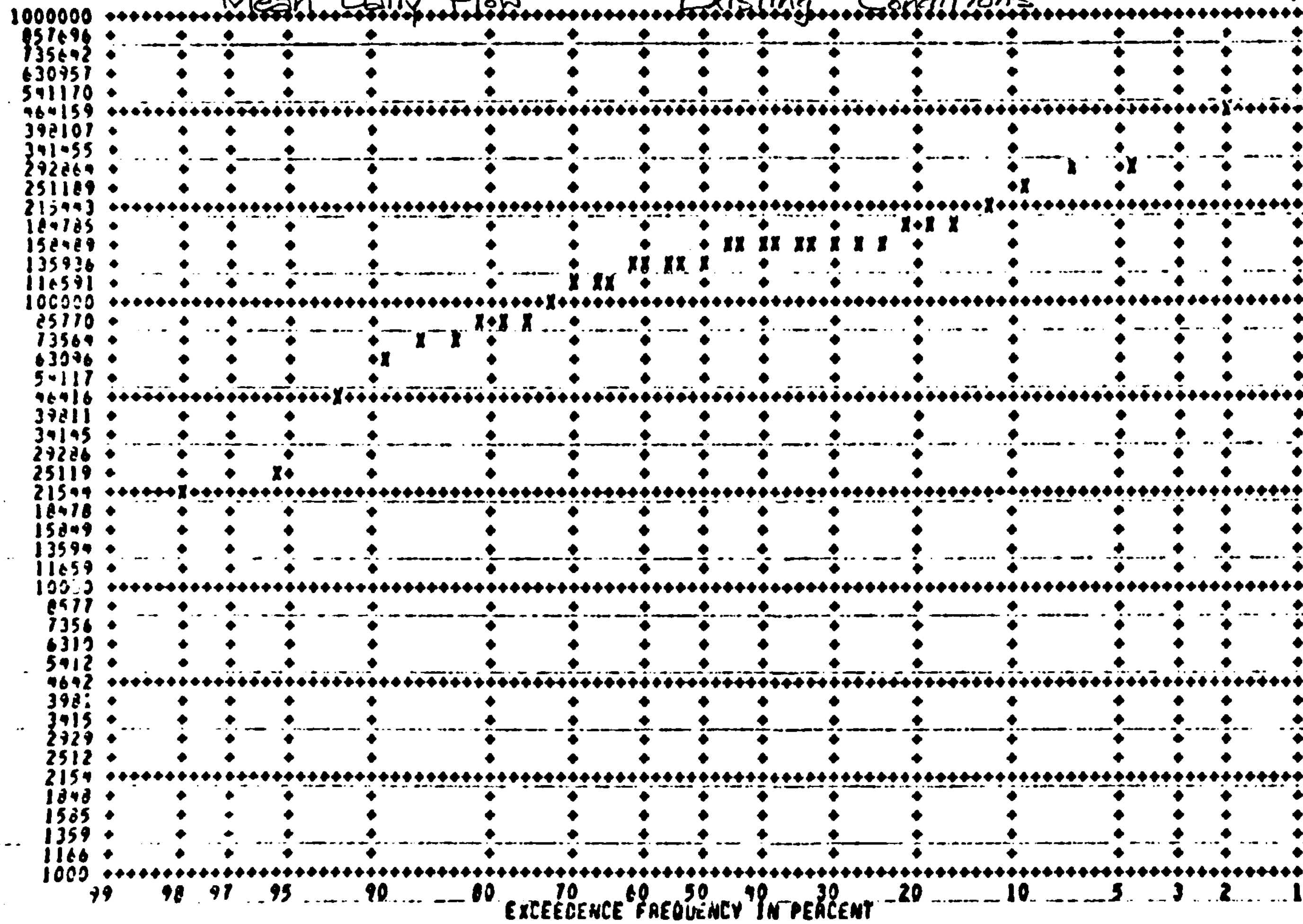
PLOT POS	VALUE
2.0	655366
4.8	610683
7.6	510923
10.4	498682
13.3	497203
16.1	439777
18.9	438752
21.7	431092
24.6	372753
27.4	340687
30.2	324308
33.0	309860
35.9	301780
38.7	268467
41.5	242822
44.3	242582
47.2	241481
50.0	232236
52.8	228850
55.7	212214
58.5	193561
61.3	190243
64.1	185203
67.0	179513
69.8	167862
72.6	135769
75.4	134518
78.3	133078
81.1	122319
83.9	113931
86.7	91137
89.6	90960
92.4	90373
95.2	52025
98.0	22789

Fig 2

00507

OZARK
ANNUAL PEAK DISCHARGE FREQUENCY

Mean Daily Flow Existing Conditions

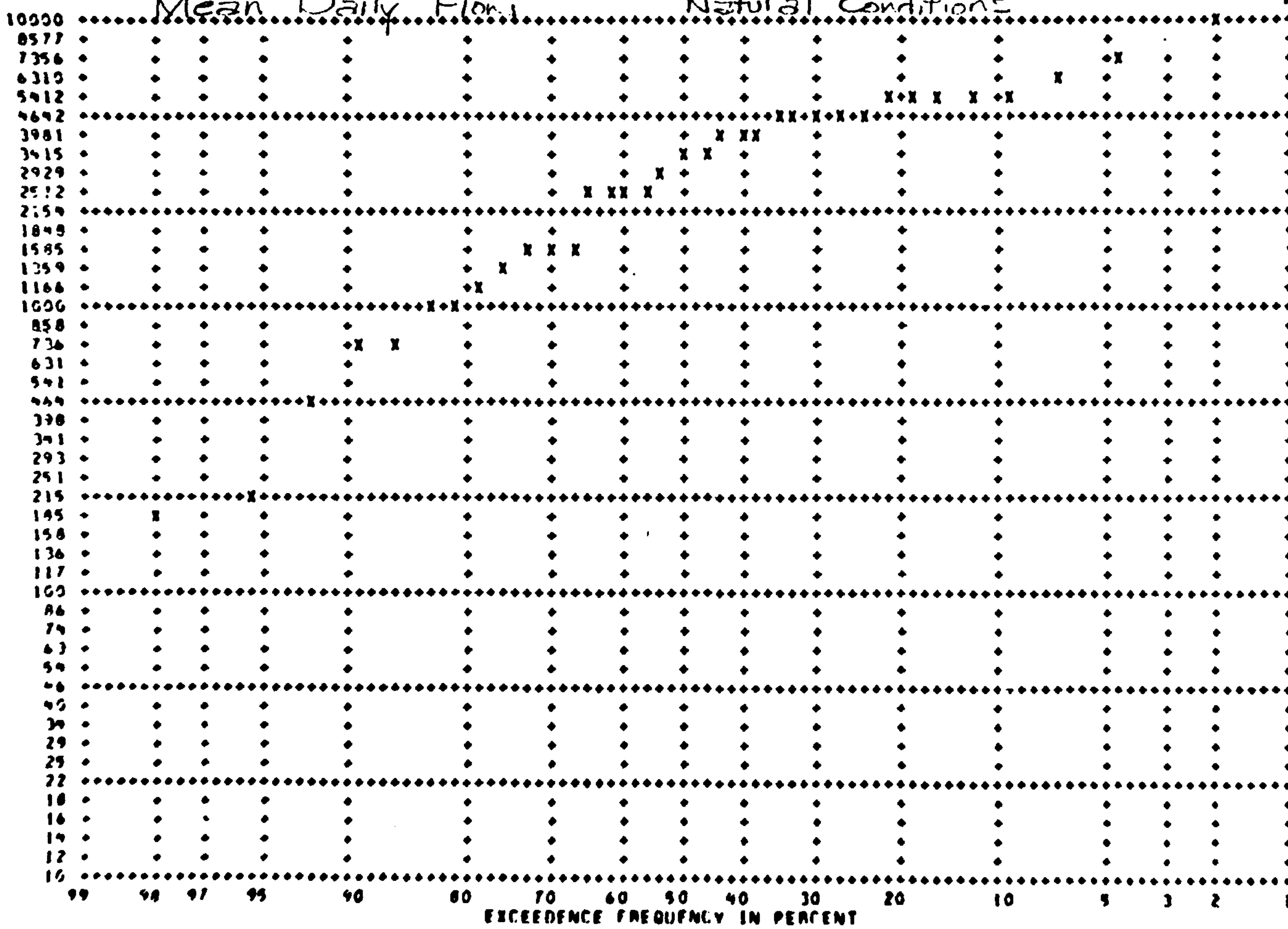


PLOT POS	VALUE
2.0	489055
4.8	298127
7.6	286380
10.4	235162
13.3	231619
16.1	191976
18.9	179110
21.7	178210
24.6	169852
27.4	162668
30.2	162558
33.0	161369
35.9	161032
38.7	153161
41.5	153098
44.3	150591
47.2	149529
50.0	142259
52.8	139456
55.7	138088
58.5	135620
61.3	132126
64.1	116732
67.0	116512
69.8	109441
72.6	103090
75.4	91839
78.3	91743
81.1	83866
83.9	74508
86.7	68939
89.6	60179
92.4	49330
95.2	23709
98.0	20519

Fig 3

OZARK OUTFLOW
ANNUAL MINIMUM DISCHARGE FREQUENCY

Mean Daily Flow — Natural Conditions



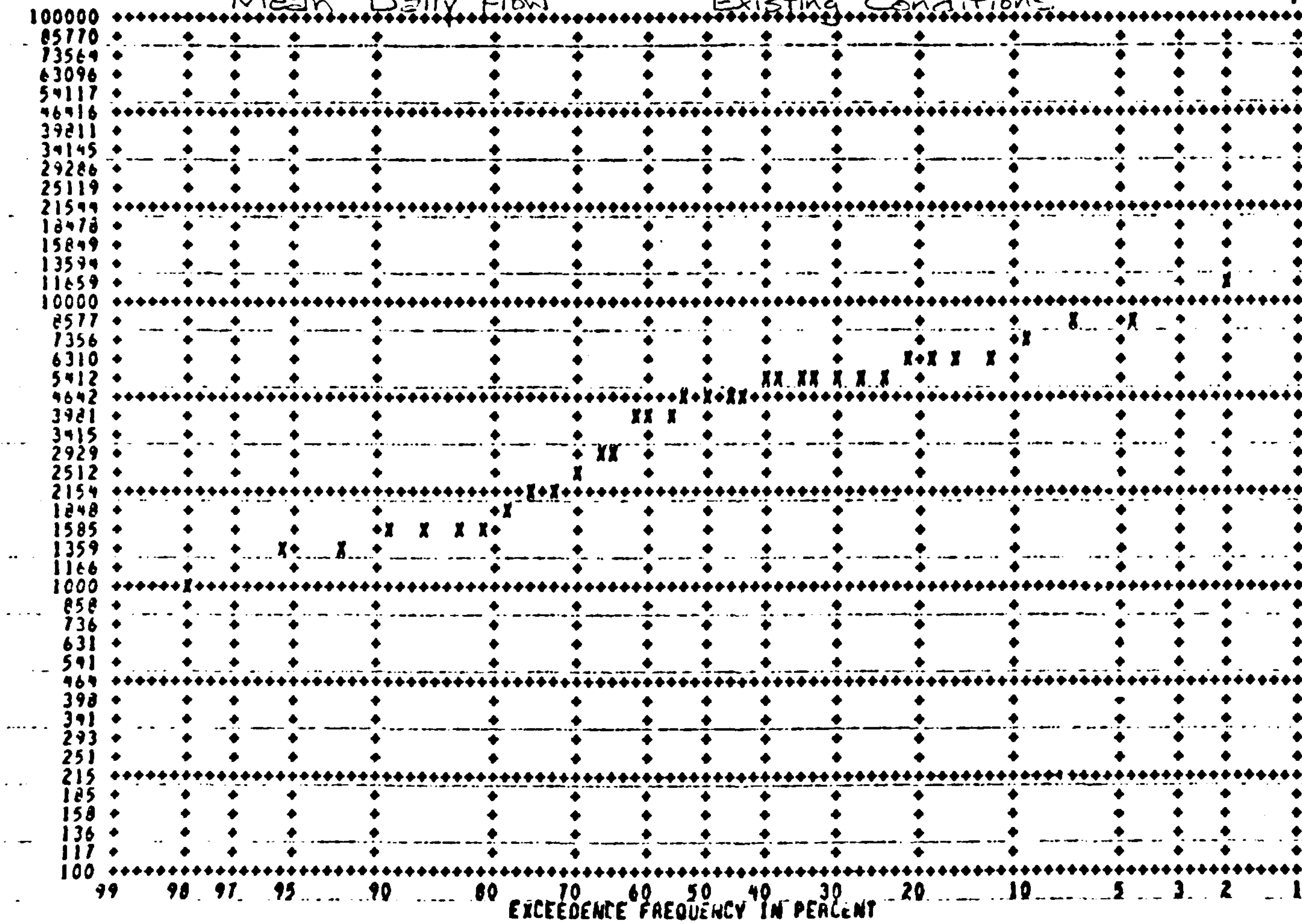
PLOT POS	VALUE
2.0	9697
4.8	6872
7.6	6410
10.4	5731
13.3	5437
16.1	5330
18.9	5309
21.7	5114
24.6	4878
27.4	4454
30.2	4419
33.0	4413
35.9	4342
38.7	4030
41.5	3858
44.3	3763
47.2	3402
50.0	3240
52.8	2970
55.7	2691
58.5	2536
61.3	2450
64.1	2410
67.0	1636
69.8	1635
72.6	1593
75.4	1435
78.3	1234
81.1	946
83.9	937
86.7	776
89.6	731
92.4	460
95.2	223
98.0	192

Fig. 4

OZARK

ANNUAL MINIMUM DISCHARGE FREQUENCY

Mean Daily Flow   Existing Conditions



PLOT POS	VALUE
2.0	11923
4.8	8125
7.6	7957
10.4	7738
13.2	6577
16.1	6424
18.9	6251
21.7	6093
24.6	5737
27.4	5574
30.2	5484
33.0	5353
35.9	5178
38.7	5125
41.5	5055
44.3	4959
47.2	4796
50.0	4721
52.8	4507
55.7	4263
58.5	4059
61.3	3746
64.1	3039
67.0	2796
69.8	2368
72.6	2178
75.4	2136
78.3	1874
81.1	1692
83.9	1591
86.7	1532
89.6	1515
92.4	1372
95.2	1345
98.0	927

Fig 5

Dardanelle Lake - Instream Flow Problems and Needs Evaluation

1. Project Name. Lake Dardanelle

2. Project Location. Dardanelle Dam is located on the Arkansas River at navigation mile 205.5, 5 miles southwest of Russellville, Arkansas. There are 153,703 square miles of drainage area above the dam. The project is operated with no controlling regulating stage or flow at the downstream stations.

3. Type of Project.

a. General. The Dardanelle Lock and Dam is a major unit in the McClellan-Kerr Arkansas River Navigation System for improvement of the Arkansas River and its tributaries in Arkansas and Oklahoma. The authorized project purposes are hydroelectric power generation and navigation. The project also offers excellent recreational opportunities.

b. Pertinent Data.

	Elevation ft. m.s.l.	Area Acres	Storage Capacity 1000 - ac-ft
Top of Power Pool	338.0	34,300	486.2
Top of Navigation Pool	336.0	31,100	420.9
Power Storage	338-336	-	65.3
Stream Bed	287.0		

c. Outlets.

Type	No. & Size	Invert El ft. m.s.l.	Opening Size & Control	Max Discharge (cfs) Top Power
Ogee Spillway	1-1210'	300.0	20 - 50'x39' Tainter Gates	658,000
Power Units	4	288.8	-	46,000

d. Power Development.

Power Units

Main Generating Units, number		4
Rated Capacity, each unit,	KW	31,000
Total	KW	124,000

4. Water Management Criteria.

a. Authorized Project Purposes. Navigation and hydropower.

b. Water Use Contracts. There is an agreement with Arkansas Power and Light allowing up to 44 cfs for cooling water losses from Nuclear No. 1, Units 1 and 2.

c. Interagency Agreements. Southwestern Power Administration markets power.

d. Informal Commitments. None.

e. System Regulation Objectives. Many of the lakes upstream from Lake Dardanelle in the Arkansas River Basin have multiple purposes. These may include two or more of the following purposes: hydropower, irrigation, recreation, fish and wildlife conservation, water supply, navigation, flood control, and water quality. The locks and dams with navigation as a purpose are regulated to provide a minimum 9-foot depth in the navigation channel from Catoosa, Oklahoma, to the confluence with the White River. Dardanelle also reregulates flows within the 2 feet of power pondage provided for generation of hydroelectric power.

5. Project Evaluation.

a. General. The period of retention of water in the impoundment is generally too short to cause any change in quality. The Arkansas Department of Pollution Control and Ecology monitors water quality along the waterway regularly and has not reported any deviation from water quality standards attributable to the impoundments or their operation. Noted problems have related to the operation of public (municipal) and private waste treatment facilities discharging into the waterway and to private industrial operations.

b. Effects of Impoundment on Water Stored. No significant effects are caused by this type of impoundment on the quality of the water.

c. Project Effects on Instream Flows. No significant effects are caused by this type of impoundment on the quality or quantity of flows. Annual discharge-duration curves for natural and existing (regulated) flows at the dam are shown in Figure 1, and annual peak and minimum discharge frequency curves are shown in Figures 2 through 5. These curves represent a computer simulation of mean daily flows for a period of record from October 1939 through September 1974.

d. Project Effects on System Regulation. The project provides for navigation on the Arkansas River and pondage for the generation of hydroelectric power.

6. Constraints on Obtaining Instream Quantity and Quality Objectives. None.

7. Alternatives. None.

8. Actions Taken to Date. None.

9. Planned Actions. None.

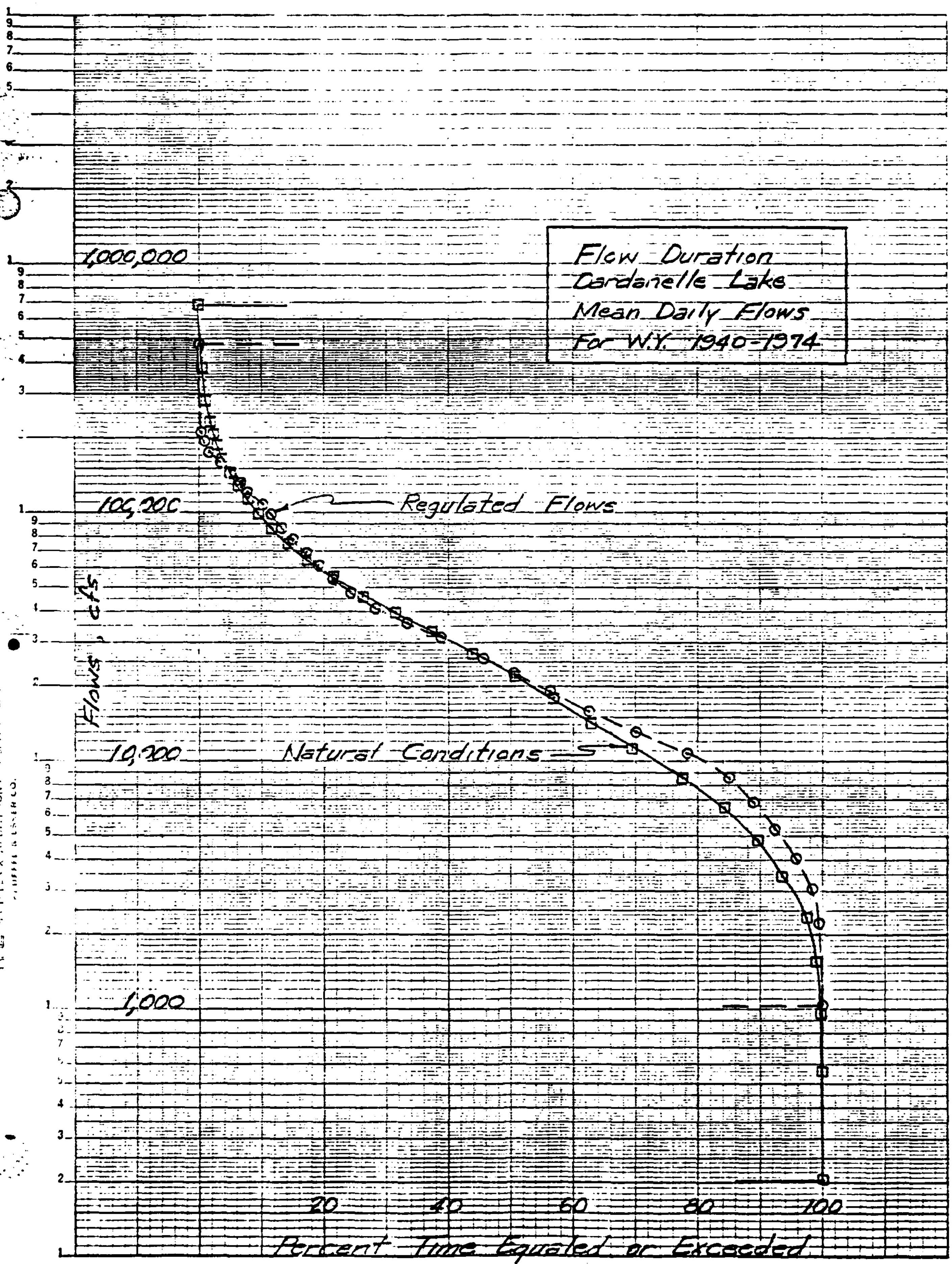
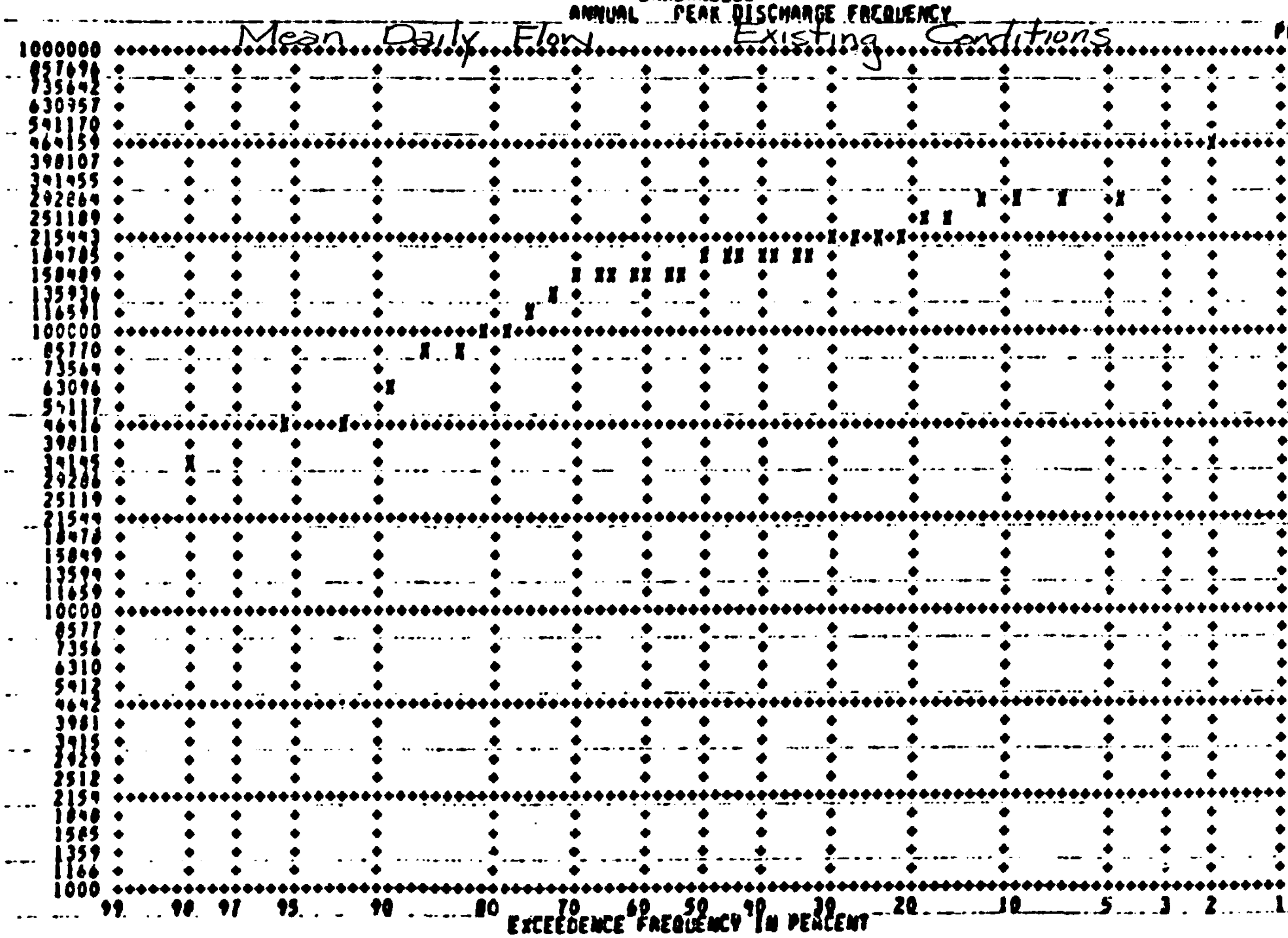

Flow Duration
Cardanelle Lake
Mean Daily Flows
For W.Y. 1940-1974
1,000,000
100,000
10,000
1,000
Regulated Flows
Natural Conditions
Flows, cfs
20
40
60
80
100
Percent Time Equaled or Exceeded

Fig. 1

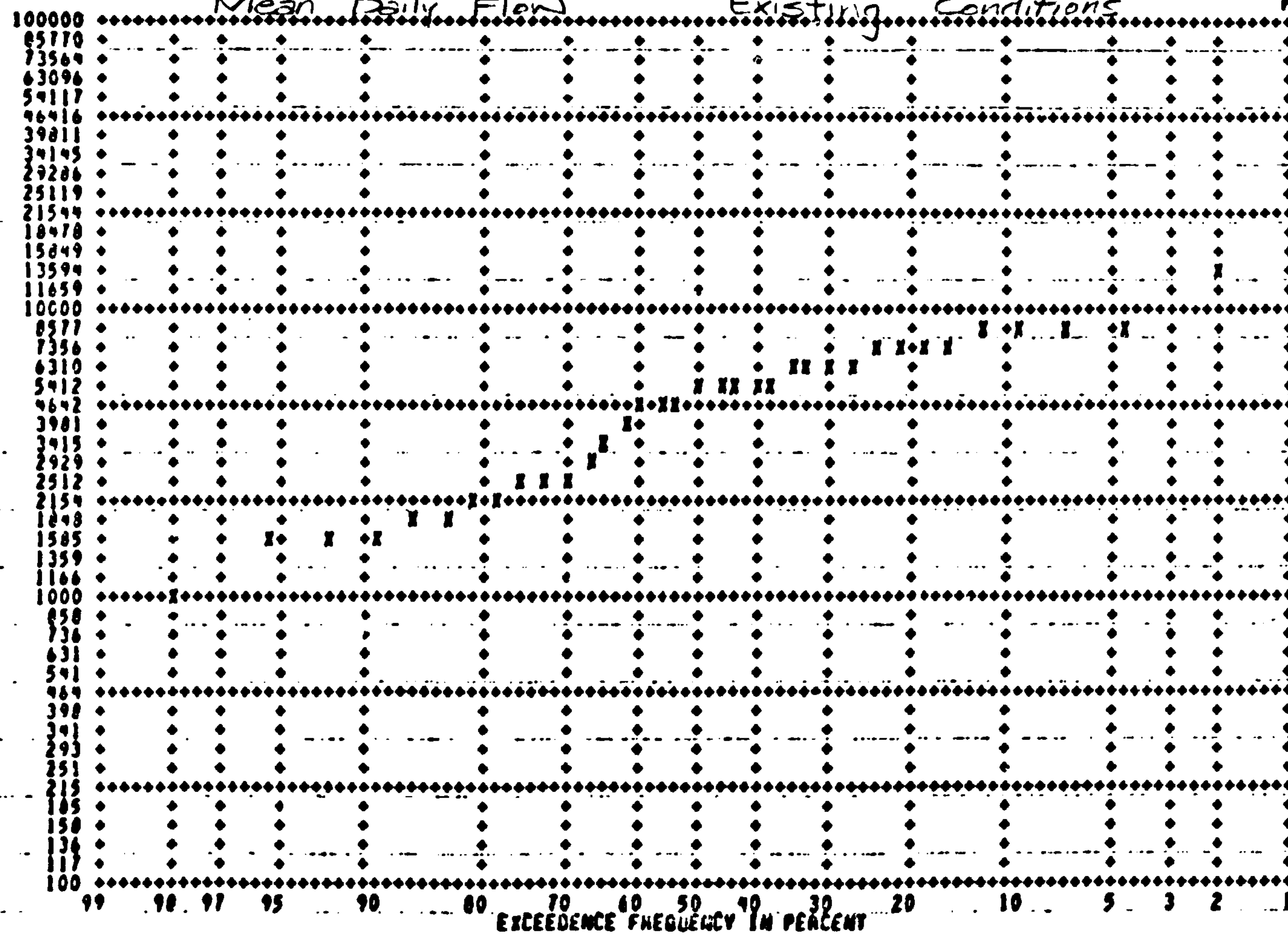
DARDANELLE
ANNUAL PEAK DISCHARGE FREQUENCY



PLOT POS	VALUE
2.0	483585
4.8	308160
7.6	305624
10.4	281528
13.3	277055
16.1	249891
18.9	233436
21.7	219143
24.6	215545
27.4	214510
30.2	202132
33.0	193677
35.9	193149
38.7	188911
41.5	185224
44.3	183690
47.2	173588
50.0	172513
52.8	168853
55.7	164951
58.5	164087
61.3	152997
64.1	152934
67.0	151283
69.8	149273
72.6	130316
75.4	115107
78.3	104666
81.1	103812
83.9	90345
86.7	83071
89.6	62130
92.4	49497
95.2	49442
98.0	33411

Fig. 2

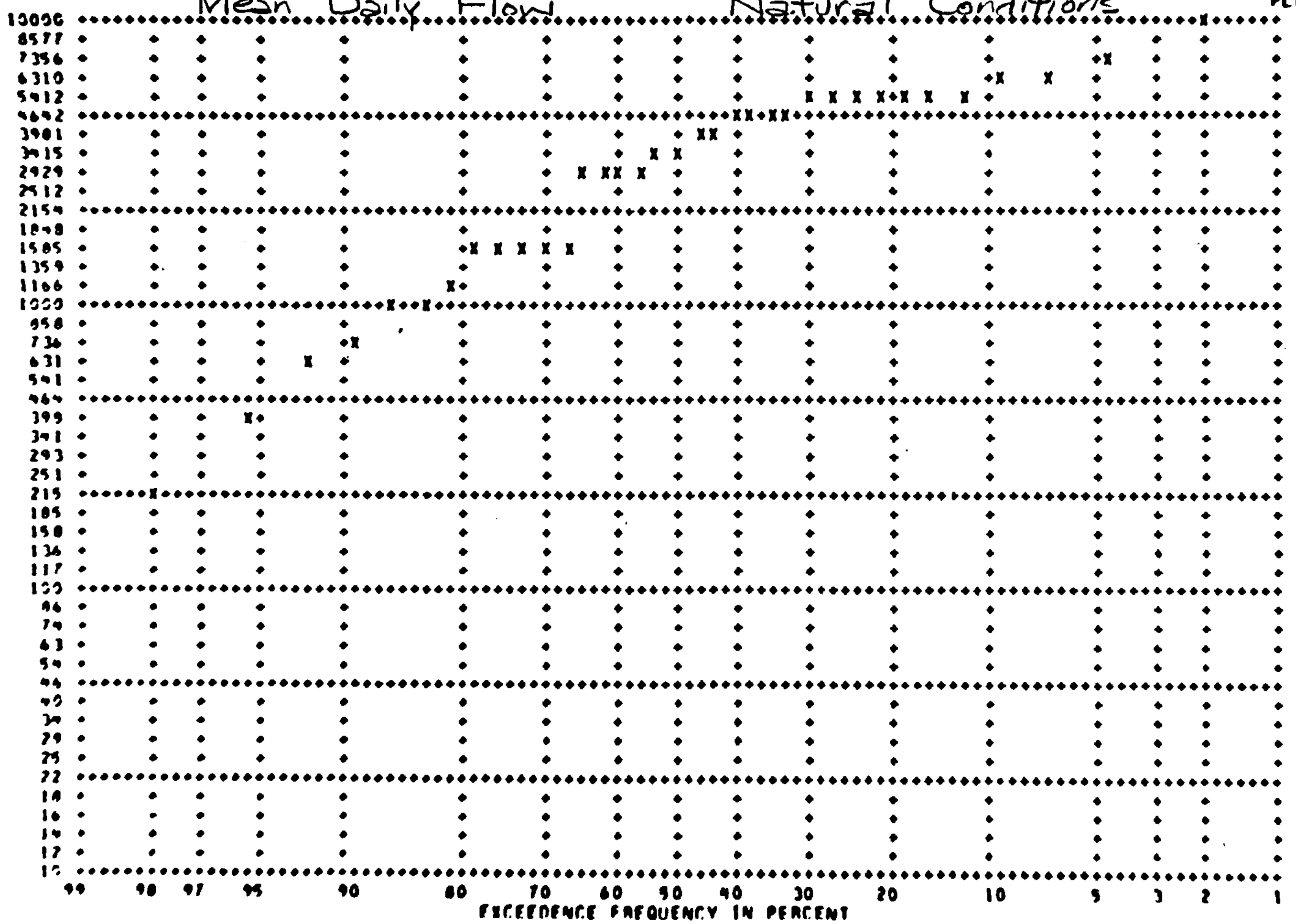
DARDANELLE
ANNUAL MINIMUM DISCHARGE FREQUENCY
Mean Daily Flow Existing Conditions



PLOT POS	VALUE
2.0	13255
4.8	8998
7.6	8657
10.4	8498
13.3	8011
16.1	7502
18.9	7453
21.7	6848
24.6	6816
27.4	6665
30.2	6661
33.0	6117
35.9	6025
38.7	5762
41.5	5496
44.3	5461
47.2	5454
50.0	5339
52.8	4673
55.7	4544
58.5	4451
61.3	4130
64.1	3325
67.0	3027
69.8	2705
72.6	2674
75.4	2338
78.3	2324
81.1	2121
83.9	1947
86.7	1797
89.6	1704
92.4	1680
95.2	1598
98.0	1015

Fig. 3

DARDANELLE OUTFLOW
ANNUAL MINIMUM DISCHARGE FREQUENCY
Mean Daily Flow Natural Conditions

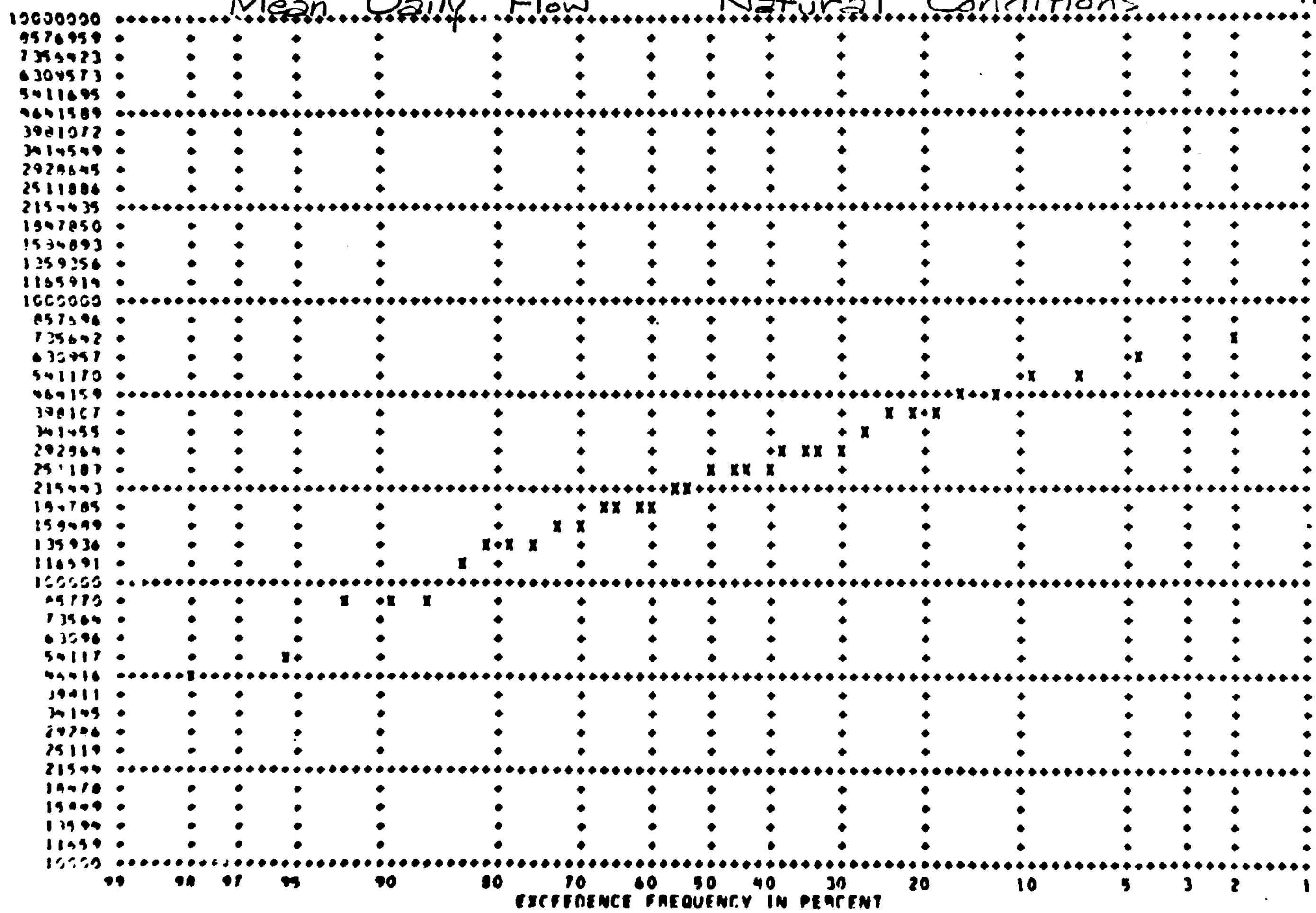


PLOT POS	VALUE
2.0	11070
4.8	7266
7.6	6532
10.4	6297
13.3	5731
16.1	5664
18.9	5475
21.7	5468
24.6	5285
27.4	5132
30.2	5132
33.0	4743
35.9	4548
38.7	4547
41.5	4363
44.3	3977
47.2	3789
50.0	3450
52.8	3387
55.7	3097
58.5	2903
61.3	2773
64.1	2728
67.0	1673
69.8	1670
72.6	1640
75.4	1573
78.3	1539
81.1	1179
83.9	1061
86.7	1045
89.6	764
92.4	646
95.2	425
98.0	251

Fig. 4

DARDANELLE OUTFLOW
ANNUAL PEAK DISCHARGE FREQUENCY

Mean Daily Flow Natural Conditions



PLOT POS	VALUE
2.0	684510
4.8	620460
7.6	511680
10.4	501832
13.3	485103
16.1	430580
18.9	429382
21.7	418714
24.6	374520
27.4	325574
30.2	311012
33.0	309409
35.9	300693
38.7	283999
41.5	258228
44.3	253884
47.2	253514
50.0	243044
52.8	224798
55.7	204030
58.5	183271
61.3	192140
64.1	174176
67.0	174112
69.8	168893
72.6	160152
75.4	138174
78.3	134436
81.1	129115
83.9	109277
86.7	89359
89.6	88773
92.4	85327
95.2	52525
98.0	44486

Fig. 5

Lock and Dam No. 2 - Instream Flow Problems and Needs Evaluation

1. Project Name. Lock and Dam No. 2

2. Project Location. Dam No. 2 is located on the Arkansas River at 1940 river mile 40.5 and Lock No. 2 is located on the Arkansas Post Canal at navigation mile 13.3. There are 160,475 square miles of drainage area of which 22,241 square miles are probably noncontributing to runoff. There are no water management control stations downstream.

3. Type of Project.

a. General. Lock No. 2 and Dam No. 2 are major units in the McClellan-Kerr Arkansas River Navigation System for improvement of the Arkansas River and its tributaries in Arkansas and Oklahoma. The authorized project purpose is navigation. The project also offers excellent recreational opportunities.

b. Pertinent Data.

	Elevation ft. m.s.l.	Area Acres	Storage Capacity 1000 - ac-ft
Top of Navigation Pool	162.0	10,600	110.0
Stream Bed	130.0	-	-

c. Outlets.

Type	No. & Size	Invert El ft. m.s.l.	Opening Size & Control	Max Discharge (cfs) Top Navigation
Flat Crest Spillway	1-1120'	134.0	16 - 60'x30' Tainter Gates	254,500

4. Water Management Criteria.

a. Authorized Project Purpose. Navigation.

b. Water Use Contracts. None.

c. Interagency Agreements. None.

d. Informal Commitments. None.

e. System Regulation Objectives. Many of the lakes upstream from Lock and Dam No. 2 in the Arkansas River Basin have multiple purposes, which may include hydropower, irrigation, recreation, fish and wildlife conservation,

water supply, navigation, flood control, and water quality. The locks and dams with navigation as a purpose are regulated to provide a minimum 9-foot depth in the navigation channel from Catoosa, Oklahoma, to the confluence with the White River.

5. Project Evaluation.

a. General. The period of retention of water in the impoundment is generally too short to cause any change in quality. The Arkansas Department of Pollution Control and Ecology monitors water quality along the waterway regularly and has not reported any deviation from water quality standards attributable to the impoundments or their operation. Noted problems have related to the operation of public (municipal) and private waste treatment facilities discharging into the waterway and to private industrial operations.

b. Effects of Impoundment on Water Stored. No significant effects are caused by this type of impoundment on the quality of the water.

c. Project Effects on Instream Flows. No significant effects are caused by this type of impoundment on the quality or quantity of flows. Annual discharge-duration curves for natural and existing (regulated) flows at the dam are shown in Figure 1, and annual peak and minimum discharge frequency curves are shown in Figures 2 through 5. These curves represent a computer simulation of mean daily flows for a period of record from October 1939 through September 1974. Although these curves are for the control point at Little Rock, they are representative of what is happening at Dam No. 2.

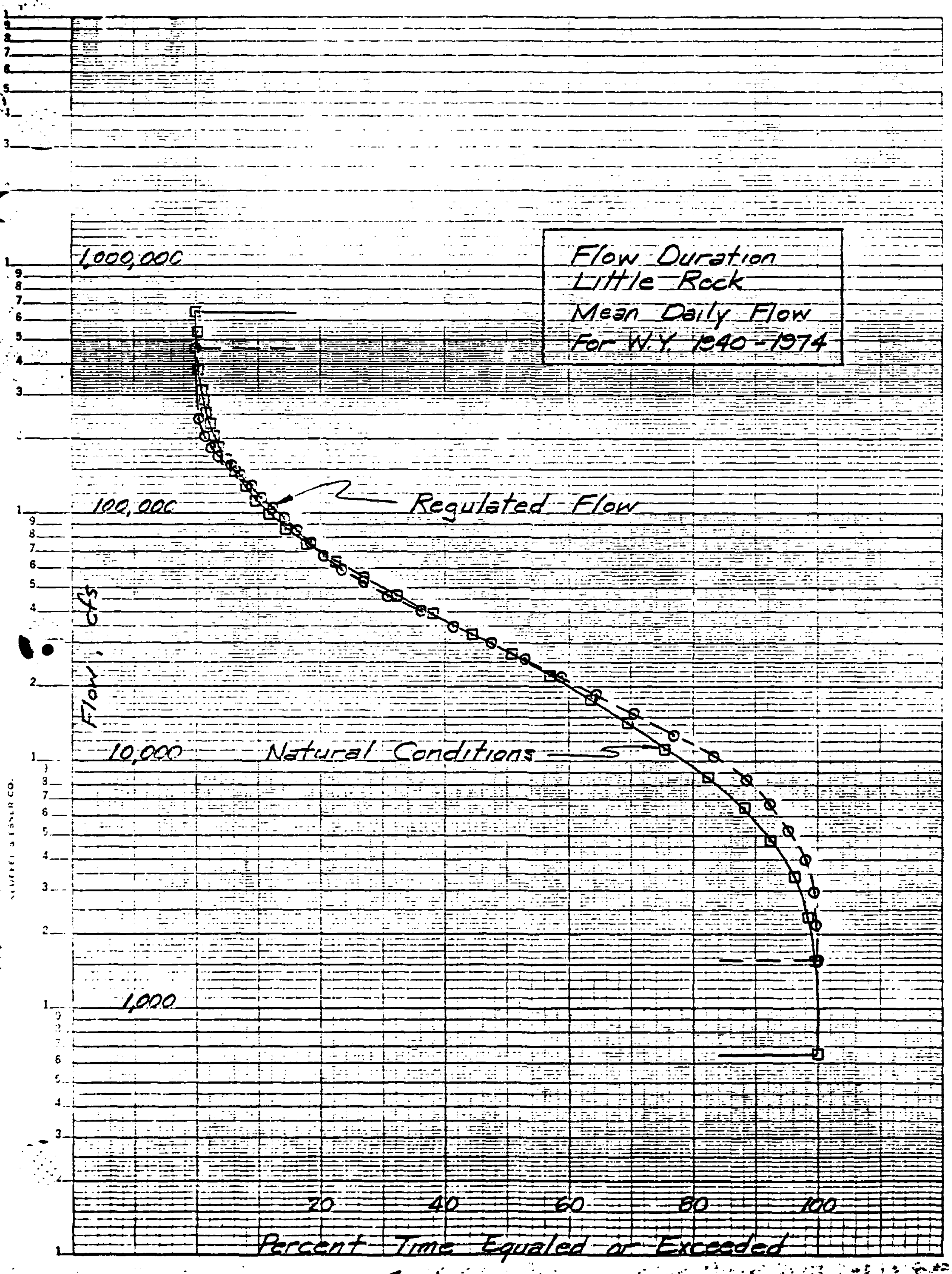
d. Project Effects on System Regulation. The project provides for navigation on the Arkansas River.

6. Constraints on Obtaining Instream Quantity and Quality Objectives. None.

7. Alternatives. None.

8. Action Taken to Date. None.

9. Planned Actions. None.



Flow Duration
Little Rock
Mean Daily Flow
For W.Y. 1940-1974
1,000,000
100,000
10,000
1,000
Regulated Flow
Natural Conditions
Flow, cfs
20
40
60
80
100
Percent Time Equaled or Exceeded

Fig 1

00521

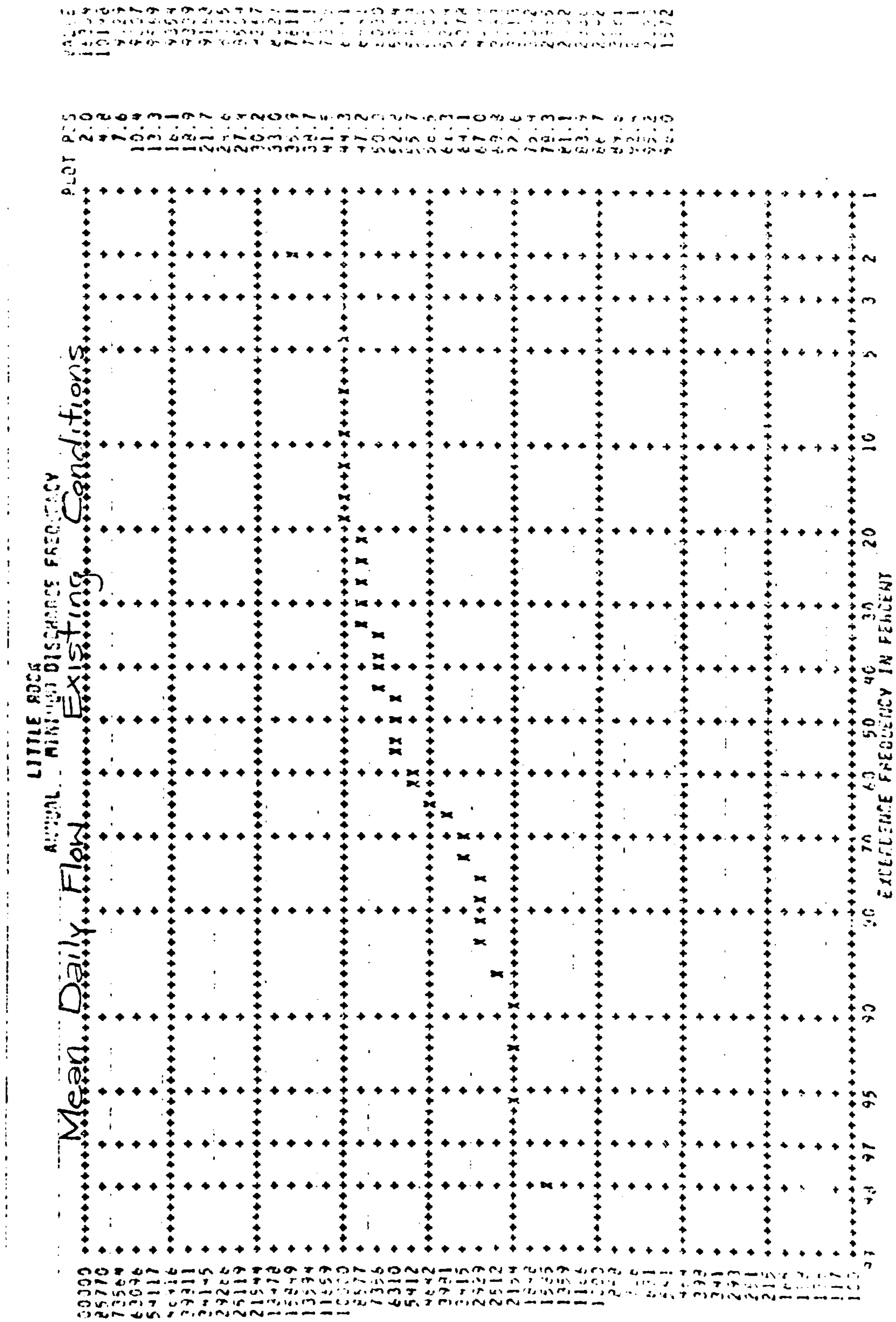

LITTLE ROCK
ANNUAL MINIMUM DISCHARGE FREQUENCY
Mean Daily Flow Existing Conditions
EXCEEDENCE FREQUENCY IN PERCENT

Fig 2

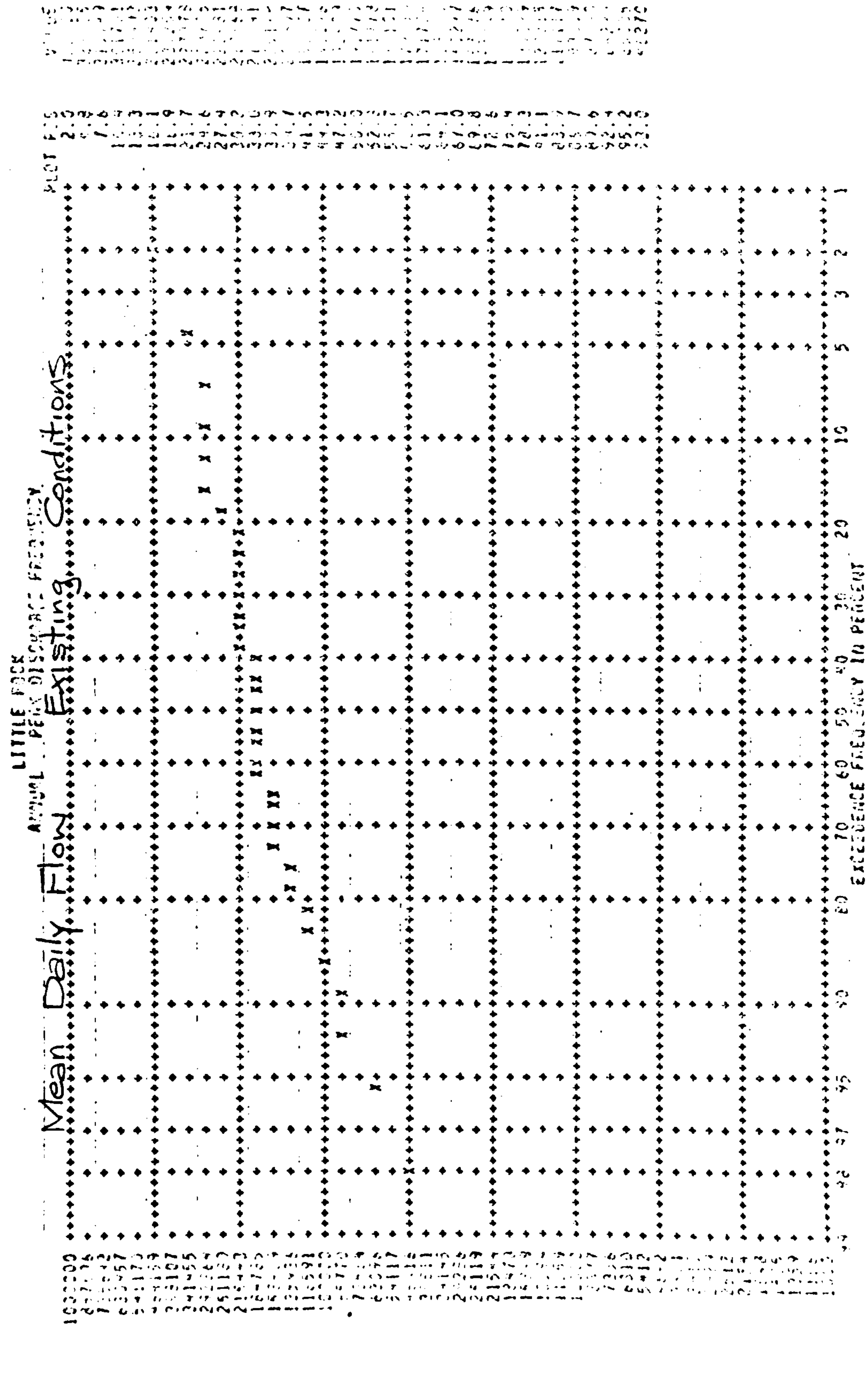

LITTLE ROCK
ANNUAL PEAK DISCHARGE FREQUENCY
Mean Daily Flow Existing Conditions
PLOT
1 2 3 5 10 20 30 40 50 60 70 80 90 95 97 98 99
EXCEEDENCE FREQUENCY IN PERCENT

Fig 3

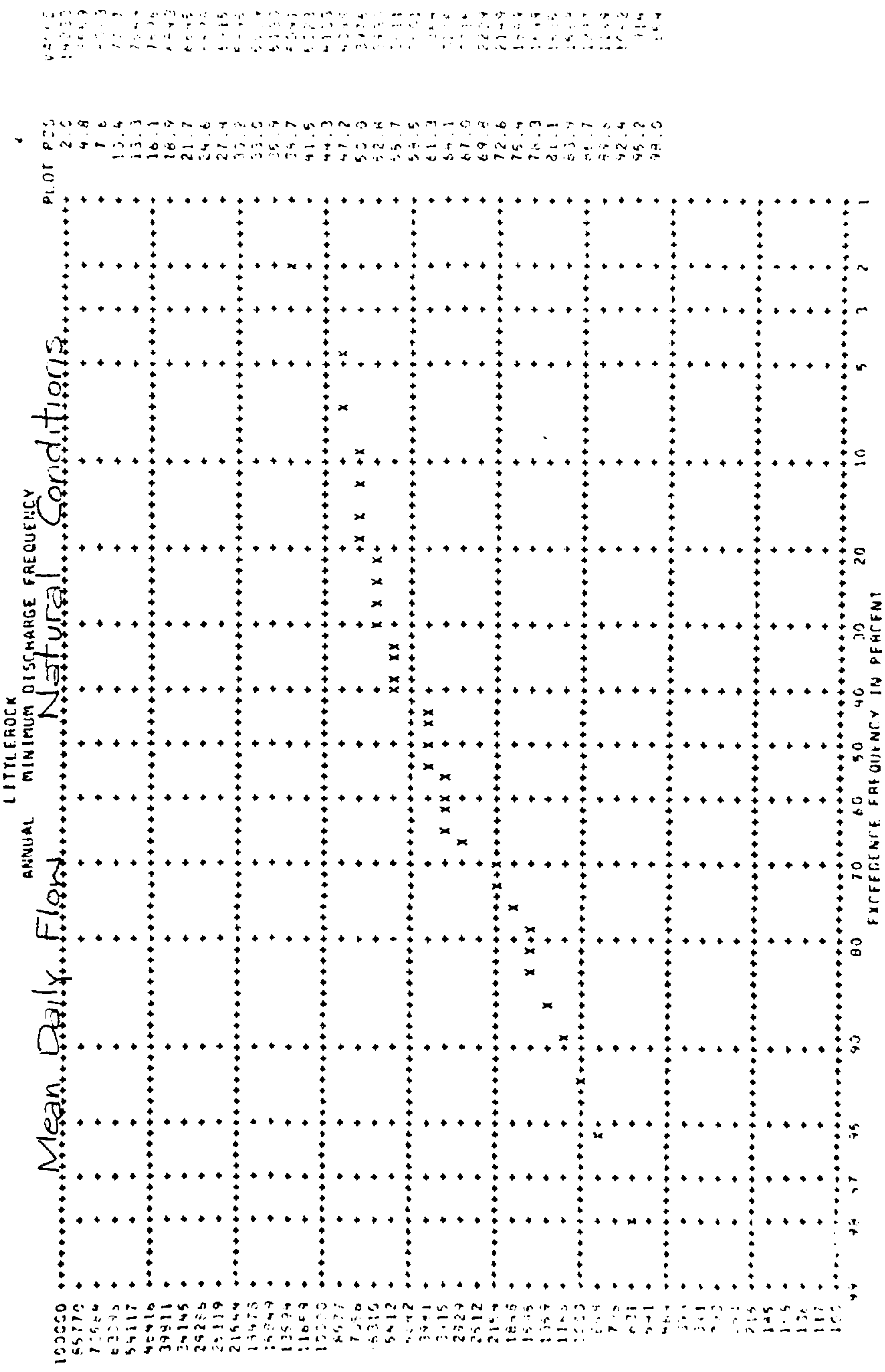
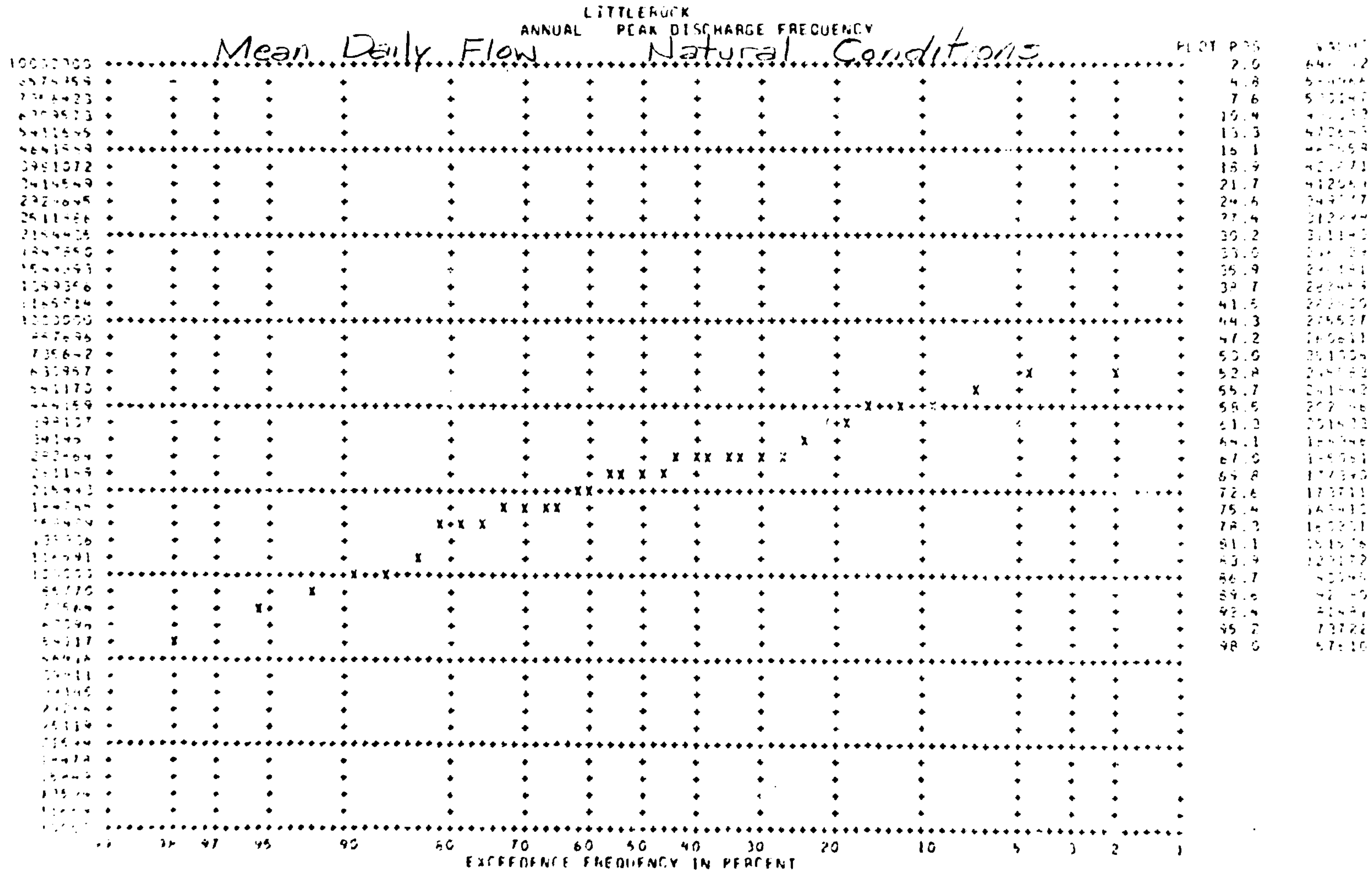

LITTLEROCK
ANNUAL MINIMUM DISCHARGE FREQUENCY
Mean Daily Flow Natural Conditions
EXCEEDENCE FREQUENCY IN PERCENT
PLOT POS

Fig 4



LITTLEROCK
ANNUAL PEAK DISCHARGE FREQUENCY
Mean Daily Flow Natural Conditions
PLOT POS
99 98 97 95 90 80 70 60 50 40 30 20 10 5 3 2 1
EXCEEDENCE FREQUENCY IN PERCENT

Fig 5

Table Rock Lake - Instream Flow Problems and Needs Evaluation

1. Project Name. Table Rock Lake

2. Project Location. Table Rock Dam is located on the main stem of the White River at river mile 528.8, about 6 miles southwest of Branson, Missouri. There are 4 020 square miles of drainage area above the dam.

3. Type of Project.

a. General. Table Rock is one of four multi-purpose projects constructed in the upper White River Basin for the control of floods, the generation of hydroelectric power, and other beneficial purposes. The project also offers excellent recreational opportunities.

b. Pertinent Data.

	Elevation ft. m.s.l.	Area Acres	Storage Capacity 1000-ac-ft	inches
Top of Flood Pool	931.0	52,300	3567.5	16.1
Nominal Top of Power Pool Top of Conservation	915.0	43,100	2702.0	12.6
Nominal Bottom of Power Pool	881.0	27,300	1520.5	7.1
Power Storage	915[1]-881	15,800	1181.5	5.5
Flood Control Storage	931-915[1]	9,200	865.5	3.5
Stream Bed	695.0			

[1]The top of the seasonal power pool will be elevation 916.0 on 1 May and 917.0 from 1 June until 1 December.

c. Outlets:

Type	No. & Size	Invert El ft. m.s.l.	Opening Size & Control	Max Discharge (cfs) Top Flood	Top Conserv
Ogee Spillway	1 - 531'(gross)	896.0	10 - 45'x37' Tainter Gates	353,000	
Sluice	4 - 4'x9'	722.0	8 - 6'x12' Slide Gates	14,540	13,970
Power Unts	4 - 18" dia	766.4	4 - 16'x23'		13,400[3]
House Unts	1 - 4' dia	769.7[2]	30" Valve		40
Hatchery	1 - 18" dia	775[2]			20

[2]Centerline elevation.
[3]At rated capacity.

d. Power Development.

Main Generating Units,	Number	4
Rated Capacity each unit,	kw	50,000
Total	kw	200,000

4. Water Management Operating Criteria.

a. Purposes. Table Rock is one of four multiple-purpose projects constructed in the upper White River Basin for flood control, hydroelectric power generation, and other beneficial purposes.

b. Water Use Contracts. None.

c. Interagency Agreements. None.

d. Informal Commitments. The Corps, Southwestern Power Administration, and the Missouri Department of Conservation have agreed that minimal daily power releases will be made for the trout fishery and flow maintenance based on air temperatures forecast by the National Weather Service (see Table 1) between 1 May and 30 September, normally, and when otherwise required by unseasonable temperatures, turbidity, stagnation, or other similar intermittent problems.

Special operations to enhance fish spawns in the White River lakes have been conducted based on Arkansas Game and Fish Commission or Missouri Department of Conservation recommendations. The first such special operation at Table Rock Lake was conducted in 1977.

TABLE 1
Minimum Releases for Trout Fisheries and Flow Maintenance

	Minimum Daily Flow (d.s.f.)				
Air Temp (°F)	Beaver	Table Rock	Bull Shoals	Norfork	Greers Ferry
90° or below	85	100	250	145	115
91-95	125	140	375	218	150
96-104	165	175	500	290	175
105+	200	200	750	360	225

The Corps and the Southwestern Power Administration have agreed that during critical times of the year, power generation will be restricted to the amount necessary to avoid lowering the dissolved oxygen of the power releases below 4 mg/l.

e. System Regulation Objectives. The overall regulation objective of the White River system is to reduce flood damages within the basin. While regulation of the system could, in general, tend to reduce the contribution of flood flow to the Mississippi River, it is not routinely possible to regulate the floods on the Mississippi because of the considerable length of crest travel times of major floods within the two systems.

When flood control storage space is in use at Table Rock and/or Bull Shoals, Beaver releases are restricted to those required for firm power. Table Rock's power releases are kept at full capacity and may be supplemented by spillway releases until such time as the remaining flood control storage in Table Rock and Bull Shoals is equal. This occurs at approximate elevations 915 and 684 ft., m.s.l., respectively. After Bull Shoals and Table Rock's remaining flood control storage is approximately equal, releases from Table Rock are reduced to maintain approximately equal amounts of remaining storage in Table Rock and Bull Shoals, subject to firm power generation at Table Rock. After Table Rock and Bull Shoals are essentially evacuated, Beaver is evacuated with releases equal to the downstream channel capacity or minimum permissible releases from Bull Shoals.

The plan of regulation provides for prorating the permissible flood control releases between the Beaver-Table Rock-Bull Shoals system on the White River and the Norfork project on the North Fork River in accordance with the percent of flood control storage in use at the time.

5. Project Evaluation.

a. General. Table Rock is one of five large White River Basin lakes which have basically similar water quality characteristics. These large deep lakes begin to stratify in late spring or early summer and remain stratified until late fall or early winter. Stratification in the lakes is very strong, with temperature differentials between the surface and bottom commonly exceeding 20°C in July.

The Missouri Department of Conservation and the U.S. Fish and Wildlife Service have established a cold water trout fishery in Lake Taneycomo, which is located directly downstream from Table Rock Lake. Construction of Table Rock and subsequent release of cold hypolimnic water eliminated the warmwater fishery in Lake Taneycomo and make the trout fishery possible.

Table 2 summarizes pertinent water quality data obtained during the period from 1974 through 1979 on the White River, the James River, on three tributaries entering the lake, in the lake just above the dam, and downstream just below the dam. It contains mean values of up to 30 measurements taken at each station.

TABLE 2
Table Rock Lake Project - WQ Data[1]

	Sample Location			
Parameter	James River	Upstream[2]	Lake[3]	Below Dam
Temperature (°C)	19	16	-[4]	9.5
Turbidity (JTU)	13	2.0	0.75	1.0
Dissolved Oxygen (mg/l)	7.3	7.2	-[4]	-[4]
Nitrites & Nitrates (mg/l)	1.02	0.64	0.39	0.53
Phosphorous (mg/l)	0.11	0.02	0.02	0.01
Fecal Coliform (#/100ml)	53	2	0	2
Iron (mg/l)	310	55	22	64
Manganese (mg/l)	140	52	22	68
Lead (mg/l)	39	38	31	35
Zinc (mg/l)	50	55	62	58

[1]Mean values of up to 30 measurements at each station (1974-1979).
[2]Average of White River and 3 tributaries entering the lake.
[3]In the lake just above the dam.
[4]Omitted because of the wide range with depth and/or season.

At certain times of the year, the lake may exhibit a somewhat unusual dissolved oxygen profile. A typical example is shown in Figure 1. The "hump" of increased dissolved oxygen concentrations in the hypolimnion is thought to be caused by a combination of oxygenated density currents due to the cooler White River inflows and an increased oxygen demand within the thermocline due to warmer somewhat eutrophic inflows from the James and Kings Rivers.

b. Effects of Impoundment of Water Stored.

(1) Positive Effects. Turbidity is low in the inflows to Table Rock and it is reduced by impoundment as seen in Table 2. Impoundment also reduces the concentrations of iron and manganese moving in the river. Fecal coliforms entering the lake from point discharge sources on tributaries or on the lake die off in the lake. Stratification of the impounded water results in sufficient cold water in the lower depths of the lake to support a trout fishery downstream.

(2) Negative Effects. Depletion of dissolved oxygen in the lower depths occurs during midsummer through fall or early winter. Under this environment objectionable compounds such as hydrogen sulfide may develop, and the leaching rate of constitutents such as iron and manganese will be increased.

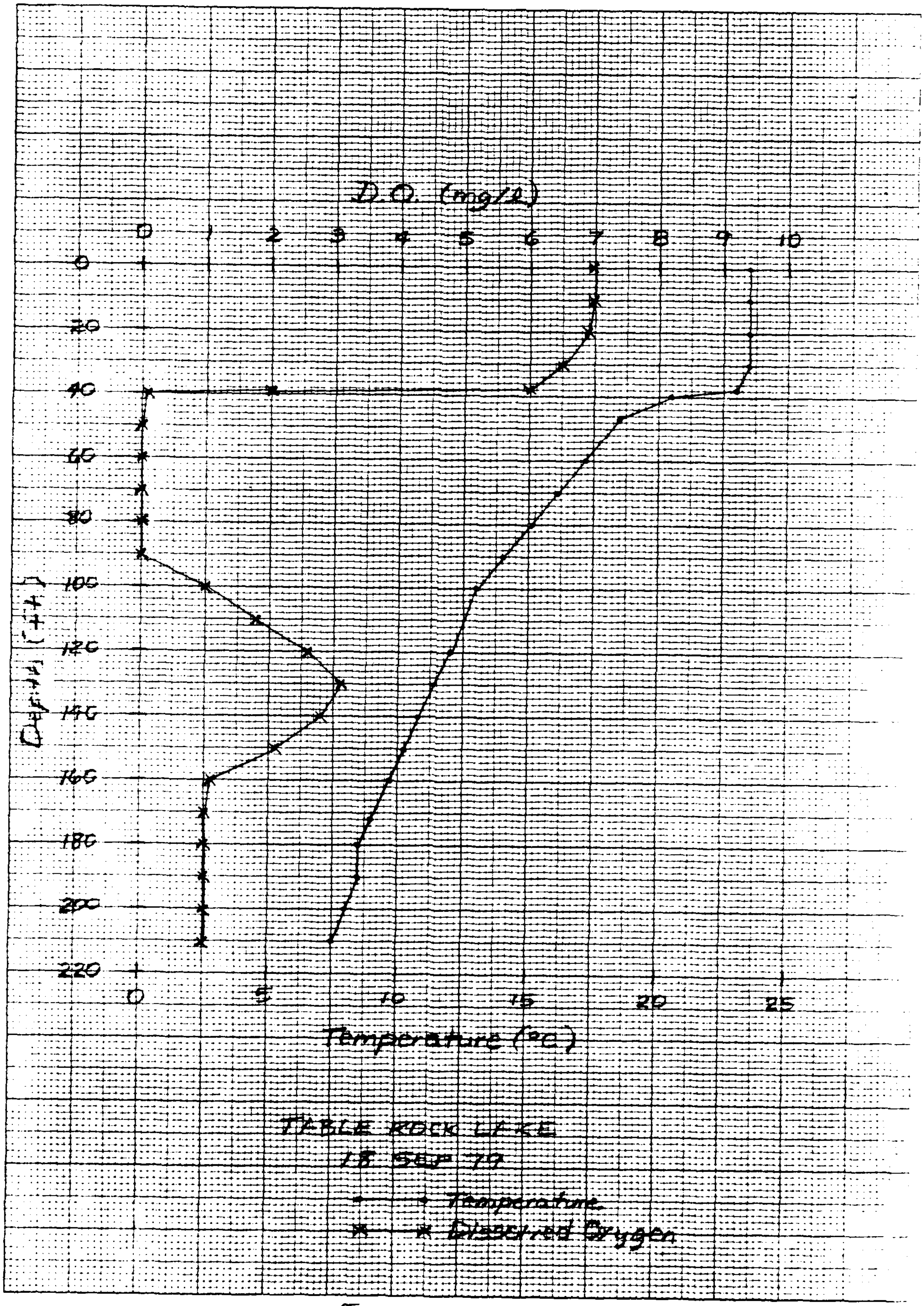

D.O. (mg/l)
0 1 2 3 4 5 6 7 8 9 10
0
20
40
60
80
100
120
140
160
180
200
220
Depth (ft)
0 5 10 15 20 25
Temperature (°C)
TABLE ROCK LAKE
18 SEP 79
Temperature
Dissolved Oxygen

Figure 1

(3) Causes of Negative Effects. Stratification results from the seasonal warming of the epilimnion. The depletion of oxygen in the hypolimnion results from the decomposition of organic material as well as isolation from surface reaeration and photosynthesis.

c. Project Effects on Instream Flows.

(1) General. Discharge-duration curves for natural and existing (regulated) flows at Table Rock Dam are shown in Figures 2 through 26. These figures represent a computer simulation of mean daily flows for a period of record from October 1939 through September 1974. Figure 2 shows both the natural and regulated annual flow duration curves. Monthly flow durations for existing and natural conditions are shown in Figures 3 through 14 and 15 through 26, respectively. Annual peak and minimum outflow discharge frequency for existing and natural conditions are shown in Figures 27-30.

(2) Positive Effects. The cold water releases have allowed the development of a very popular trout fishery. The flood control operation reduces high flows and the subsequent flood releases increase the duration of flows around bankfull and lower (15,000 - 600 cfs) downstream within Lake Taneycomo. Low flow releases from the project are considerably greater than those before the project.

(3) Negative Effects. Occasionally releases are deficient in dissolved oxygen, particularly in the late summer to early winter during periods of hydroelectric power generation. Because the releases enter directly into Lake Taneycomo rather than a series of natural shoals, reaeration is delayed. The depressed oxygen levels in Lake Taneycomo have adversely affected the trout fishery. Because of the importance of this fishery to the overall area economy, there has been considerable interest in eliminating or lessening these adverse impacts.

(4) Causes of Negative Effects. The occasional release of oxygen deficient water is due to lake stratification and the level in the lake from which the water is withdrawn. This situation is worsened within the lake by the inflow of oxygen-demanding organic material from the James River and worsened downstream by the lack of a series of natural shoals providing reaeration.

6. Constraints on Obtaining Instream Quantity & Quality Objectives.

a. Quantity. Power releases vary significantly depending on generation demands. Boat dock owners and recreational users of Lake Taneycomo want minimal lake level fluctuations.

b. Quality. There is a very significant conflict between generation of hydroelectric power and maintaining suitable DO levels in the releases. Efforts to prevent the power releases from dropping below 4 mg/l disolved oxygen has required that generation of hydropower be restricted to less than 50 percent of capacity.

7. Alternatives.

a. Reservoir Regulation. The present regulation plan, although generally adequate for downstream needs, is being reevaluated as part of the White River Lakes Study described in paragraph 8.

b. Structural Modification. A variety of structural modifications have been considered to improve the dissolved oxygen levels in the Table Rock releases. These include reservoir destratification, hypolimnion reaeration, selective withdrawal, aeration within the turbine, downstream channel aeration, and others.

c. Storage Reallocation. One alternative considered was the use of supplemental reservoir releases, either from the spillways or sluices. If implemented, this alternative could require storage reallocation.

d. Other. NA.

8. Actions Taken to Date. Various alternative operating plans, including storage allocations, are being addressed in the White River Lakes study. A comprehensive study of the Table Rock dissolved oxygen problem is being conducted jointly by the Corps and other agencies. The Missouri Department of Conservation is completing a biological and economic evaluation to determine the effects of varying levels of dissolved oxygen in Lake Taneycomo in relation to fisherman use and harvest and the economy of the area. The results will be used to quantify the benefits of increasing dissolved oxygen in the Table Rock releases. Numerical simulation models of both Table Rock Lake and Lake Taneycomo have been developed. These will be used to determine the effectiveness of various alternative methods of increasing the dissolved oxygen.

9. Planned Actions. Alternatives are being screened for technical and economic feasibility. Those selected for further study will be evaluated using the previously developed models. Thus it will be possible to develop a "benefit-cost ratio" for the various alternatives.

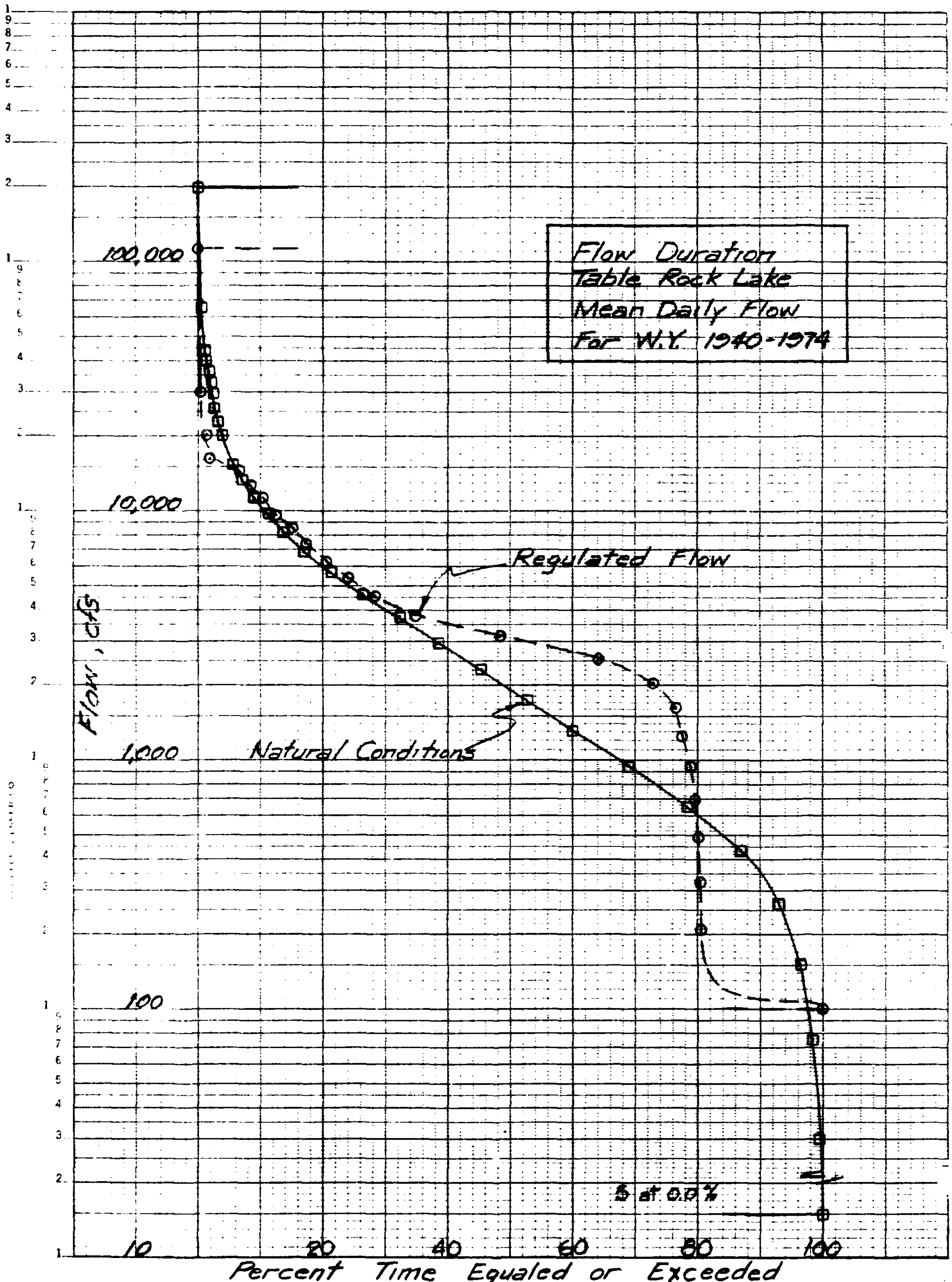

Flow Duration
Table Rock Lake
Mean Daily Flow
For W.Y. 1940-1974
100,000
10,000
1,000
100
Flow, cfs
Regulated Flow
Natural Conditions
10
20
40
60
80
100
Percent Time Equaled or Exceeded

Fig. 2

END

FILMED

8-85

DTIC